PUBLISHED BY THE INSTITUTE OF FOOD TECHNOLOGISTS

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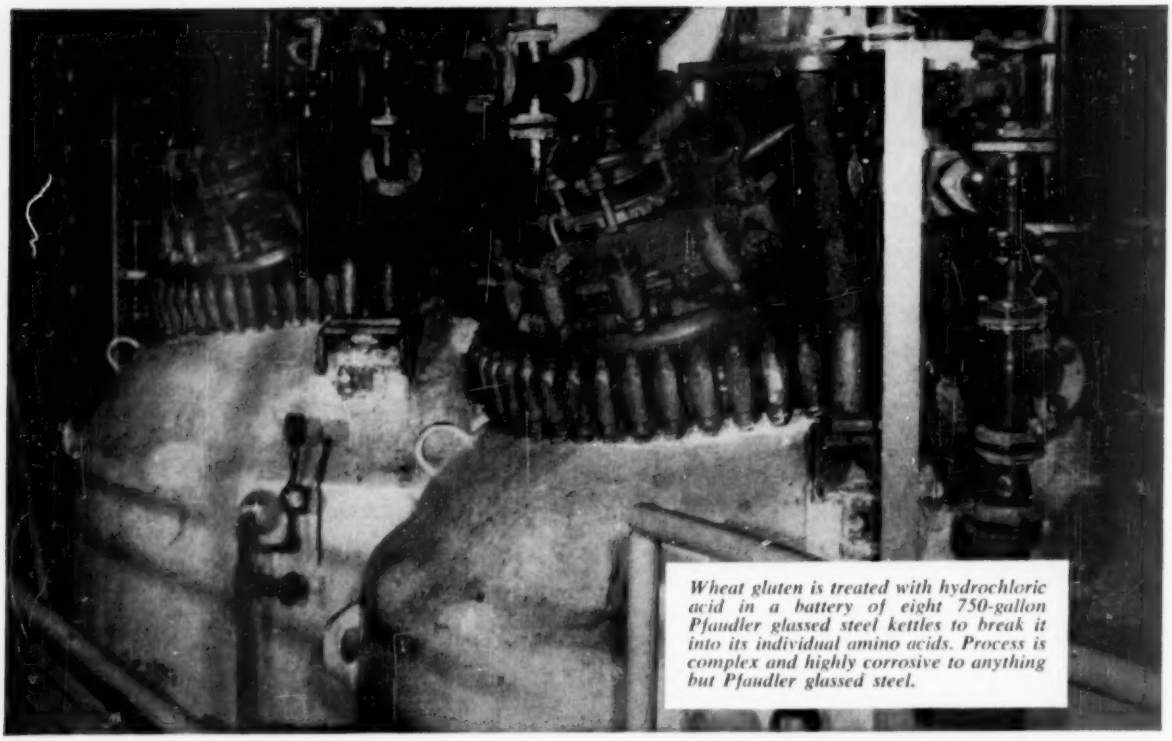

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# Affairs of the Institute


Announcement of Samuel Cate Prescott Award Competition
Use of Artificial Sweeteners in Food
News of the Regional Sections
Personnel
Annual Meeting Bulletin Board
Books
Selected Abstracts
Food Industry Topics
Future Meetings


## Announcement of Samuel Cate Prescott Award Competition for Student Members of the Institute of Food Technologists

The Samuel Cate Prescott Award in Food Technology was established by the Northeast Section of the Institute of Food Technologists to honor Doctor Samuel C. Prescott, outstanding research worker in the field of Food Technology and outstanding teacher with a great interest in youth.

This award, given for the purpose of stimulating the interest of young men and women in Food Technology is offered annually by the Northeast Section of the Institute of Food Technologists for the best written account of a research project in the field of Food Technology. This may be, preferably, but not necessarily, a research project conducted by the author.

Those eligible for the competition include all student undergraduate members of the Institute of Food Technologists in good standing, who are rated as seniors during the academic year 1953-1954, and who will receive a Bachelor's Degree in Food Technology prior to July 1st, 1954. This Degree shall be represented by training in such courses as physics, chemistry, mathematics, bacteriology, and engineering fundamentals.

The prize shall be One Hundred Dollars.

The Committee reserves the right to withhold any award if none of the papers are of the quality deemed satisfactory by the judges.

Competitors are to submit their written papers to:

James Donovan, Chairman
Northeast Section, Institute of Food Technologists
c/o Artisan Metal Products, Inc.
73 Pond Street, Waltham 54, Massachusetts

previous to December 1st, 1954.

The essay shall be submitted in duplicate, typewritten on paper of good quality, double-spaced, and not less than 6 nor more than 15 pages in length.

## Use of Artificial Sweeteners in Food to be Studied by NRC Food and Nutrition Board

The Food and Nutrition Board, National Research Council, meeting on November 6-7, heard reports from sixteen of its active committees. The Board considered the request from The Commissioner of the Food and Drug Administration for advice on the problem as to how the extensive use of artificial sweeteners in foods may be expected to affect the nutritional welfare of the public. The board decided to deal with the question in three phases:

(1) The Board's Committee on Definitions and Standards of Identity for Foods will explore the possibility of forming representative industry groups to confer with Food and Drug officials on development of proposals for definitions and standards of identity for canned fruits sweetened with saccharin or sucaryl instead of sugar, dextrose and corn sirup, as now provided by standards.

(2) The Committtee on Food Protection will evaluate the safety of sweeteners and the additives used in conjunction with them.

(3) A special committee, to be appointed, will study and report on policies which would serve to direct the use of artificially sweetened products in the best interests of the nutritional welfare of the public.

The Board gave consideration and approval of the program projected for the Food Protection Committee during 1954, which included among the objectives (1) advisory assistance to industry and government on the development and control of chemical additives in foods; (2) the development of better criteria and methods for establishing the safety of food additives; and (3) the encouragement of the kinds of research necessary to conform to the established basic principles.

## Regional Section News

### CHICAGO SECTION

Following a succulent chicken dinner, 94 Section members were formally convened by Chairman Brissey at 7:50 P.M. in the Illinois Room of the Palmer House. Included in the group were three West Coast visitors, one gentleman from Montreal, and five of our past chairmen.

PAST IFT PRESIDENT, DR. ROY NEWTON, RECEIVES COMMEMORATIVE GAVEL FROM CHAIRMAN BRISSEY.

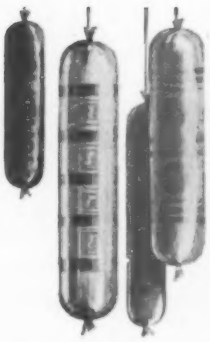
SPEAKER OF THE EVENING, DR. EMIL MRAK, UNIVERSITY OF CALIFORNIA.

*Pictures by Lloyd Slater*

First event on the program was the formal presentation of a suitably inscribed gavel by Chairman Brissey to Past IFT President Dr. Roy Newton. Dr. Newton then responded with some enjoyable reminiscences of the inception and early days of IFT. He noted how much time was spent in those days groping for the definition of a Food Technologist and on such fundamentals as: "Just what is a Food?," and "Is chemistry a food operation?"

(Continued on page 6)

## Now! Shorten Curing Time



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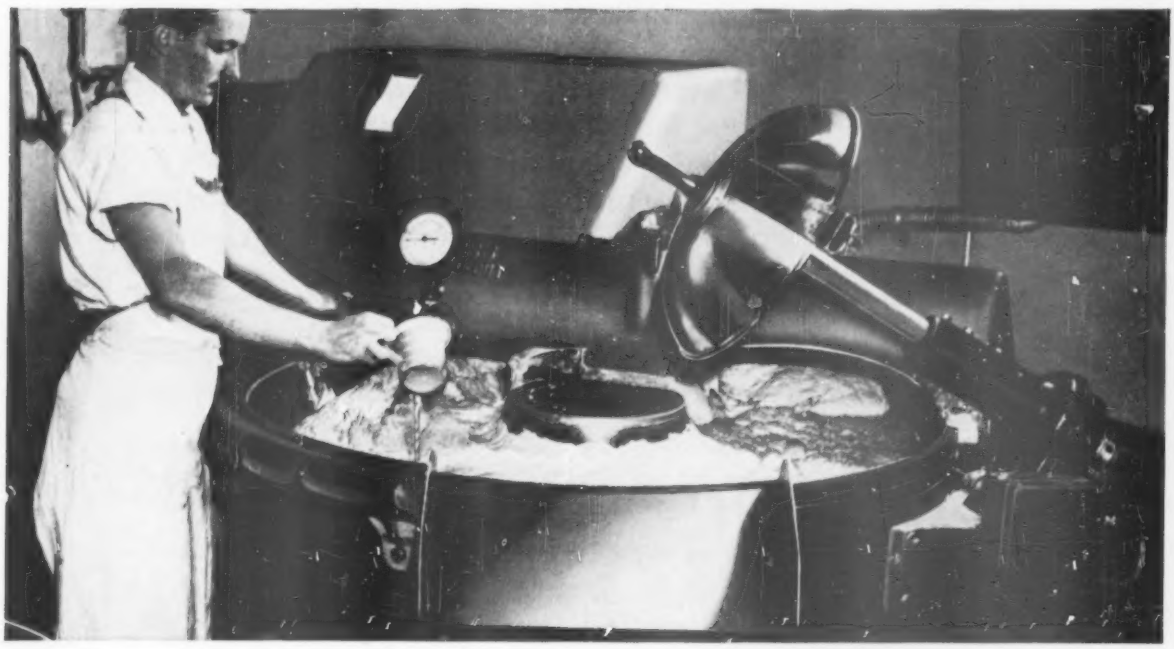

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# —to promote better health

TO promote better health, mere enactment of laws is insufficient. Experience has shown that effective education of the public in nutritional matters depends to a great extent on the dissemination of the principles of nutrition, food values and related subjects. If the public is properly educated, it will naturally prefer the *improved* staple foods over those which are lacking in good nutritional value.

THE practice of enriching or fortifying foods for better health is becoming more widespread. For example, enrichment of many cereal foods, the fortification of certain fruit and vegetable juices, and of margarine, are accomplished facts in the United States. The list lengthens because food processors know that, fundamentally, the most important factor in foods is nutritive value. So they are making their good foods better—to the benefit of millions of people.

THE firm of Hoffmann-La Roche has for many years pioneered in the production of vitamins for the food and other industries throughout the world. These vitamins, synthesized by chemists, are identical with those existing naturally and are manufactured on a large scale at a much lower cost than if they were extracted from natural sources. These are the vitamins that are used for flour and bread enrichment, the process which to a great extent restores important nutritional values which are unavoidably lost in the milling and processing of wheat when fine, white flour is produced. Rice, corn and other cereal grains are similarly restored and fortified.

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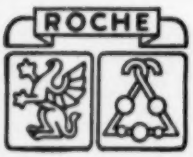


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## REGIONAL SECTION NEWS

(Continued from page 2)

And in closing, our Past President left us with this thought: "After all, it's too early in our history to reminisce—let's give IFT another 25 years before praising or condemning it."

Next, Vice Chairman Brockington introduced the eminent speaker of the evening, Dr. Emil Mrak of the University of California—noting as he did so that the good Emil still managed to draw a sizable crowd despite the title of his talk ("The Love Life of the Fig and Its Wasp").

Dr. Mrak's discourse was fascinating—and its title was proven to be very definitive. First he described the birth of the fig industry in California and some of the problems in propagating the imported Smyrna fig which employed sex rather than self-fertility in its life cycle. The fact was that this fig of normal yearnings created some tremendous problems in sanitation due to its habit of relying on the assistance of a small, unimaginative wasp in its sex life.

Using slides, Dr. Mrak showed how the Food Technologists who helped straighten out this fig's dilemma employed the tools of physics, chemistry, agronomy, biology, and fig and wasp psychiatry.

One interesting aspect of the very complicated sex life of this fig is the role played by the ugly little male wasp. This fellow spends all his days grubbing down inside the spongy inedible male Smyrna. His only pleasure is to dig a hole to the surface of this fruit, fertilize the female, and give her directions on how to get out to the world through his tunnel.

Following Dr. Mrak's delightful talk a short business session was held. First the minutes of the preceding meeting were accepted as printed in the *Newsletter*. Then Col. Isker read off the list of candidates for Section Offices selected by his committee—to be voted on by our membership before the December meeting. No additional nominations were made from the floor and the slate was accepted by those present *in toto*.

Secretary L. Slater highlighted the proceedings of that afternoon's Executive Committee meeting. A Tellers Committee, consisting of E. Nordlinger, Chmn., Mrs. Rolle, and G. J. Foss was selected to count our election votes. Also a committee was set up with Milt Parker as Chairman, including Virgil Wodicka and C. E. Norton, to develop material on Nicholas Appert for use by future Medalists in their talks. An added item of business was the proposal to add a tithe of 25c to forthcoming '54 dues to cover the cost of a Section Directory—this will be subject to membership approval at our December meeting.

## PHILADELPHIA SECTION

The second meeting of the 1953-54 season was held at Drexel Institute on November 5 and 69 members and guests attended the meeting. Mr. Pratt, our Vice-Chairman, gave a report to the meeting on the programs planned for the remainder of the season. Dr. Obold, reporting for the Employment Committee, stated that there were several positions available for Food Technologists. Mr. Hans Dresel told about the position as Research Associate now being offered by the Pennsylvania Manufacturing Confectioners Association. Dr. E. F. Kohman entertained the meeting with a very interesting tale of his trip to Hawaii. Our speaker for the evening, Dr. Lloyd Hall, was then introduced by Mr. Pratt. Dr. Hall discussed "Some Aspects of Control and Stability of Food Flavor." In his discussion, Dr. Hall explained the effects on food flavor of such characteristics as volatility and oxidation.

Features of the December Meeting (ladies night) will be a movie in color "Viva Mexico" and an address by Mr. George Garnatz, Director of the Kroger Food Foundation, Cincinnati, entitled "Science and Your Food."

## DIXIE SECTION

*Dixie Section Meets with National Biscuit Company.* On November 20, the Dixie Section was guest of the National Biscuit Company in Atlanta, Georgia. After a luncheon in the cafeteria, a tour of the mammoth new plant occupying 830,000 square feet of space located on Murphy Avenue was made, under the supervision of trained guides. After the tour Mr. Robert Sanford, Assistant Manager gave a lecture on, "History and Development of the Baking Techniques of the National Biscuit Company."

Mr. Sanford described in detail the evolution of the baking industry from the "cracker barrel" stage of 1890 through the highly efficient, completely mechanized plants of today, with a capacity of more than five million crackers per an eight-hour shift.

He discussed the growth of baking ovens from the stationary type through the reel type, the open plate type, solid plate type, to the present day chain traveler type. The modern oven has heat from both the top and bottom and the belt conveying the crackers moves through the 300 foot oven in which they are cooked, cooled, and conditioned in 3 to 7 minutes. The millions of crackers baked simultaneously in six mammoth ovens are never touched by human hands.

After being mixed and delivered to the ovens, the dough is rolled, reduced to the varying thicknesses, and the crackers are molded to the desired size and delivered immediately to the long chain conveyors that pass through the ovens. Leaving the oven they are automatically sorted, counted, packaged, sealed, cased, and delivered to the warehouse within a few minutes.

Mr. Sanford emphasized that the three conditions that make the operations successful are: efficient mechanical operation, strict sanitation throughout the plant, and highly developed safety devices.

He described that crackers are made from sweet dough and sponge dough. They are carefully compounded and placed in proofing rooms for 24 hours with rigidly controlled humidities and temperatures. He stated that this company uses annually: 800 million pounds of butter, 50 million pounds of eggs, 4½ million pounds of cheese, and 8½ million pounds of figs.

He summarized by saying that 35 of the 65 billion pounds of food consumed is in packages, and "our challenge is to keep pace with food organizations whom we supply."

(Continued on page 8)

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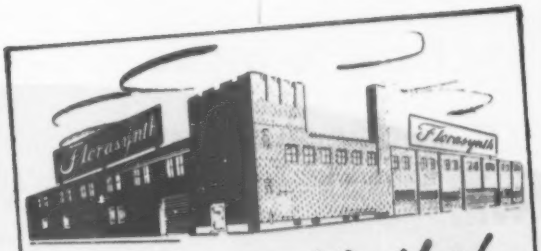


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## REGIONAL SECTION NEWS

(Continued from page 6)

### NEW YORK SECTION

The November meeting of the New York Institute of Food Technologists took place at the Brass Rail on Wednesday, November 18th.

At the conclusion of a short business meeting, Mr. Schaal, Chairman of the Section, presented Dr. Charles N. Frey with the permanent gavel which all past National Presidents of IFT are to receive.

Dr. Lauren B. Hitchcock, formerly President of the National Dairy Research Laboratories and previously Vice-President in charge of the Chemical Department of Quaker Oats Company, addressed the Section, the title of his talk being "How To Waste Money Efficiently."

Under the guise of a delightful and witty irony, Dr. Hitchcock presented a great deal of important and interesting material on the problems and relationships of research to management, advertising and sales departments. The lively question period which followed Dr. Hitchcock's talk gave ample evidence of the interest with which the Section heard his remarks.

### AUSTRALIA NORTHERN SECTION

The main feature of the November meeting of the Section, which was held on November 3rd, was an inspection of the newly completed C. S. R. Chemicals Plant at Rhodes, N. S. W. The plant, which represents an investment of $10 million manufactures acetic acid, acetic anhydride, ascorbic acid and cellulose acetate. Food technologists were impressed by the multiplicity of automatic controls that were used, and by the scale of the operations. After the inspection, the group repaired to the C. S. I. R. O. Laboratories at Homebush where a buffet dinner was served, and this was followed by the screening of a number of techincal films on aspects of food manufacture.

Dr. Victor M. Lewis, Secretary of the Section, has been granted a leave of two months from his duties, during which time he will be in Yugoslavia acting in an advisory capacity for the F. A. O. In his absence the Secretarial duties will be taken over by the Treasurer, Mr. E. G. Davis.

### AMES SECTION

The Section held its Fall Meeting on Tuesday, November 3, 1953. The members met for luncheon in the new dining room of the Memorial Union at Iowa State College. Mr. J. W. Coverdale, Rath Packing Company, Waterloo, Iowa gave an interesting talk on "The Pork Chop."

In the afternoon session the following papers were given:

1. "Applications of the Oxycat to Industry" by A. I. Bratten, Oxy-Catalyst, Inc., Wayne, Pa.

A discussion of the application of the catalyst in its various forms to industrial processing plants, particularly for control of air pollution in the food industry.

2. "Waste Disposal Problems and Their Relation to the Corn Wet Milling Industry" by Mr. L. H. Peetz, General Operating Superintendent, Clinton Foods, Inc., Clinton, Iowa.

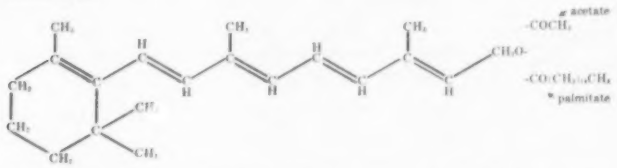
The discussion covered the following: A brief resumé of the wet milling process (as background), early waste

(Continued on page 10)

*Notes from the makers of*
**Myvax Vitamin A**

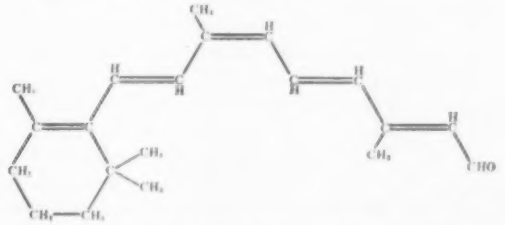
# Vitamin A in the dark

This is the active, principal, and vital ingredient in the Myvax Vitamin A which we make in bulk and put up as Myvapack Vitamin A for the individual requirements of margarine manufacturers:




That it helps people and animals grow properly and maintain their epithelial tissues in sound condition has long ago passed out of the area of doubt. Instead of just taking these wonderful attributes for granted, we maintain a staff of organic chemists, biochemists, and biologists who keep busy putting out papers, correspondence, and samples to their scientific colleagues interested in exploring the molecular architecture represented above.

It turns out, for example, that in the body some of the vitamin A develops a twist and turns up in the retina of the eye in a *cis* form of the aldehyde, possibly:




In the dark this—and only this—combines with the protein opsin to form the pigment rhodopsin. The action of light in bleaching the rhodopsin back to vitamin A aldehyde and opsin is responsible for our ability to see in dim light. The strange thing is that when the vitamin A aldehyde comes out of the rhodopsin it is back in the straight, all-*trans* form preferred by nature's and man's synthetic processes.

It is not at all strange that the famous university biologist who reported this turned to us for certain of the data and experimental preparations of vitamin A isomers which he needed in his research. Doing and assisting basic research we regard as part of the responsibility that comes to us as old hands in the vitamin A field.

The rest of the responsibility is to keep the quality of Myvax Vitamin A at the top and the service flawless in promptness and convenience to customers old and new. This, too, we never shirk. ***Distillation Products Industries,*** Rochester 3, N. Y. Sales offices: New York and Chicago • W. M. Gillies and Company, Los Angeles and San Francisco • Charles Albert Smith Limited, Montreal and Toronto.

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**Distillation Products Industries** *is a division of* **Eastman Kodak Company**

## REGIONAL SECTION NEWS

(Continued from page 8)

disposal practices, present-day waste disposal techniques and the specific relation of waste disposal to the Clinton Foods' plant location.

3. "Some Observations with Regard to Dairy Waste Disposal" by Prof. V. H. Nielsen, Dept. of Dairy Industry, Iowa State College.

A resumé of a project on dairy waste disposal at Iowa State College, together with other dairy waste disposal practices.

4. "Clarification of Industrial Wastes by Flotation" by Mr. R. I. Berman, Manager, Midwest Division, Buckley, Dunton Processes, Inc., New York, New York.

A discussion of the treatment of packing house and cannery wastes.

The following members were elected to office for 1954:

Chairman: Glen E. Cooper, Rath Packing Company, Waterloo, Iowa.
Vice Chairman: Emerson Bird, Dairy Industry Dept., Iowa State College, Ames, Iowa.
Secretary-Treasurer: Frances Carlin, Foods and Nutrition Dept., Iowa State College, Ames, Iowa.
Section Councilor: Wayne Montgomery, Penick and Ford, Cedar Rapids, Iowa.
Executive Committee: M. H. Taras, C. A. Swanson & Sons, Omaha, Nebraska; R. T. Carey, Ocoma Foods Co., Omaha, Nebraska; O. J. Cotterill, Poultry Dept., Iowa State College; and J. Meader, Continental Can Co., Des Moines, Iowa.

## MARYLAND SECTION

The Section's November meeting was held on Friday, November 13, 1953, at the Stafford Hotel with fifty-six members and guests present. Dr. Berton S. Clark, IFT national president, was the speaker of the evening. After briefing the members on Institute affairs at the National level, Dr. Clark discussed recent advances in can fabrication. The discussion of the part played in the past by plates made with light weight tin coatings and the future forecast for this type of tin plate was most illuminating.

## WESTERN NEW YORK SECTION

The Buffalo Area Group of this Section held its second dinner meeting on Monday, December 7, 1953, at the Buffalo School of Applied Arts and Sciences, Buffalo, N. Y. It took the form of a joint meeting with the Cereal Chemists of the area. Guest speaker was Mr. R. L. Lloyd, Sales and Technical Service Dept., American-Maize Products Co. His talk covered the many and varied functions of starches and sugars in the Food Industry.

## PERSONNEL

MARTIN BURKE (M.S. in Food Technology, I. S. C.) formerly with Tobin Packing Company, Fort Dodge, Iowa is now Food Technologist with Hormel in Fort Dodge, Iowa.

RICHARD FORSYTHE (Ph.D. in Food Technology, I. S. C.) formerly with the Research Division, Armour and Company, has accepted a position with Henningsen Inc., Springfield, Missouri.

DR. GLADYS EVERSON, who was Professor of Foods and Nutrition at I. S. C. became Head of the Home Economics Department at the University of California, Davis, California.

STANLEY L. BALLONN was appointed Assistant Professor of Poultry at I. S. C. He was formerly with the Research Division of Armour and Company, Chicago, Illinois.

ROBERT H. THOMAS (Ph.D. in Food Technology, I. S. C., August, 1953) is now Assistant Professor, Dairy Industry Department, University of Nebraska, Lincoln, Nebraska.

R. L. HANDWERK (Ph.D. Food Technology, I. S. C.) after 2½ years in Japan in Q. M. C. is in the Research Division of Kraft Foods, Glenview, Illinois.

ALLAN KRAFT (Ph.D. December 1953 Food Technology) has taken a position with B. A. I. Poultry Division, U. S. D. A., Beltsville, Maryland.

HENRYK HURWICZ (Ph.D. July, 1953 Food Technology) is now employed by the Trane Company, LaCrosse, Wisconsin, in the research division.

TOM HURST (Ph.D. August 1953, Food Technology) is with A. E. Staley, Manufacturing Company, Decatur, Illinois, in the research division. His main concern is the development of new food products from soybean and corn.

LT. COL. CARL R. FELLERS, head of the food technology department at the University of Massachusetts, will be honored at a joint Air Force-Army ROTC parade and review on Alumni Field November 10. The state university educator retires this month after 30 years' active and reserve service with the Army. During World War II he was chemical officer at Ft. Devens and later chief of subsistence laboratory and food inspection in the South West Pacific theater. He has taught at the command and general staff school, the chemical warfare school and the Army subsistence school. In 1950, Col. Fellers received the Babcock Award of the Institute of Food Technologists and the Award For Merit from the Cuban government. At present he heads the state university's new program in food management and fisheries technology.

DR. C. EDITH WEIR, who for the last four years has been identified in research with the United States Department of Agriculture at the Agricultural Research Center, Beltsville, Md., has joined the staff of the American Meat Institute Foundation as chief of the division of home economics, it is announced by H. R. KRAYBILL, Foundation director of research and education.

DR. U. J. LEWIS, who recently returned to the United States following post-doctoral research studies in Hugo Theorell's Laboratory in Stockholm, Sweden, has also joined the staff (division of biochemistry and nutrition) of the American Meat Institute Foundation; he will also be a member of the department of biochemistry of The University of Chicago. The Foundation is a research organization affiliated with the University of Chicago.

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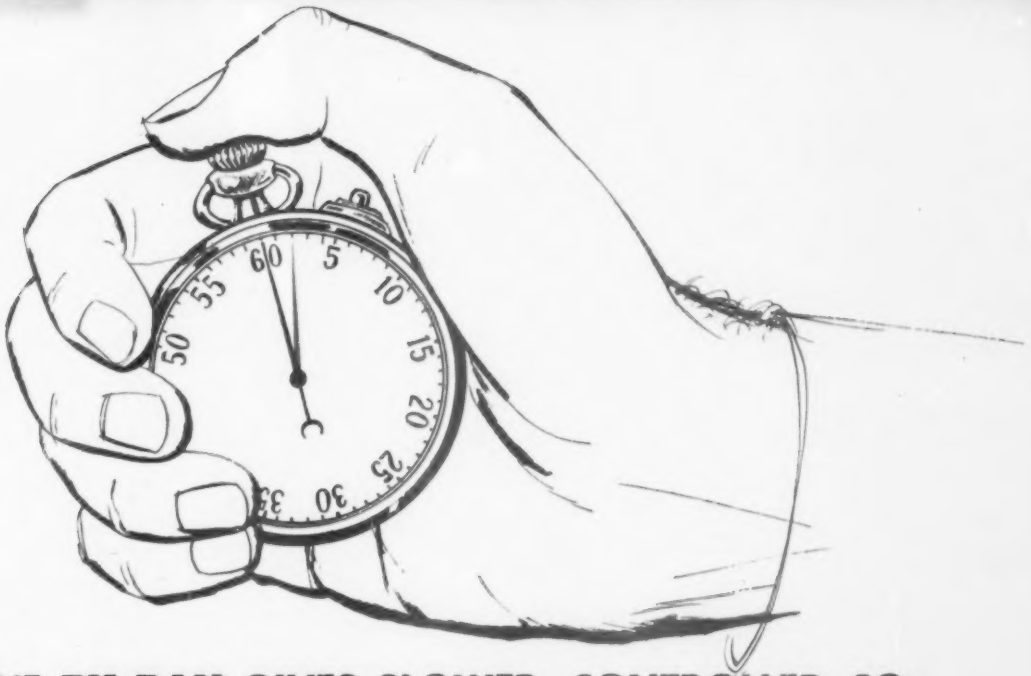
## Tests Show Greater Stability of PY-RAN Increases Volume of Baked Goods

**PY-RAN'S' stability increases product shelf life.** Your customers get light, fluffy biscuits like these, as PY-RAN controls the effects of aging. Aging tests conclusively prove PY-RAN'S superior stability increases the life of prepared mixes and self-rising flour. A special coating seals out moisture and retards premature reaction. Deteriorated, rejected products are reduced to a minimum.

**Fluffy or thin,** you can get exactly the type pancake you want for your mix by using PY-RAN or Monsanto HT phosphate or a blend of both.

**Longer shelf life for cake mixes** results when PY-RAN is used. And best of all, PY-RAN blends unusually well with SAPP to give exactly the formulation you desire.



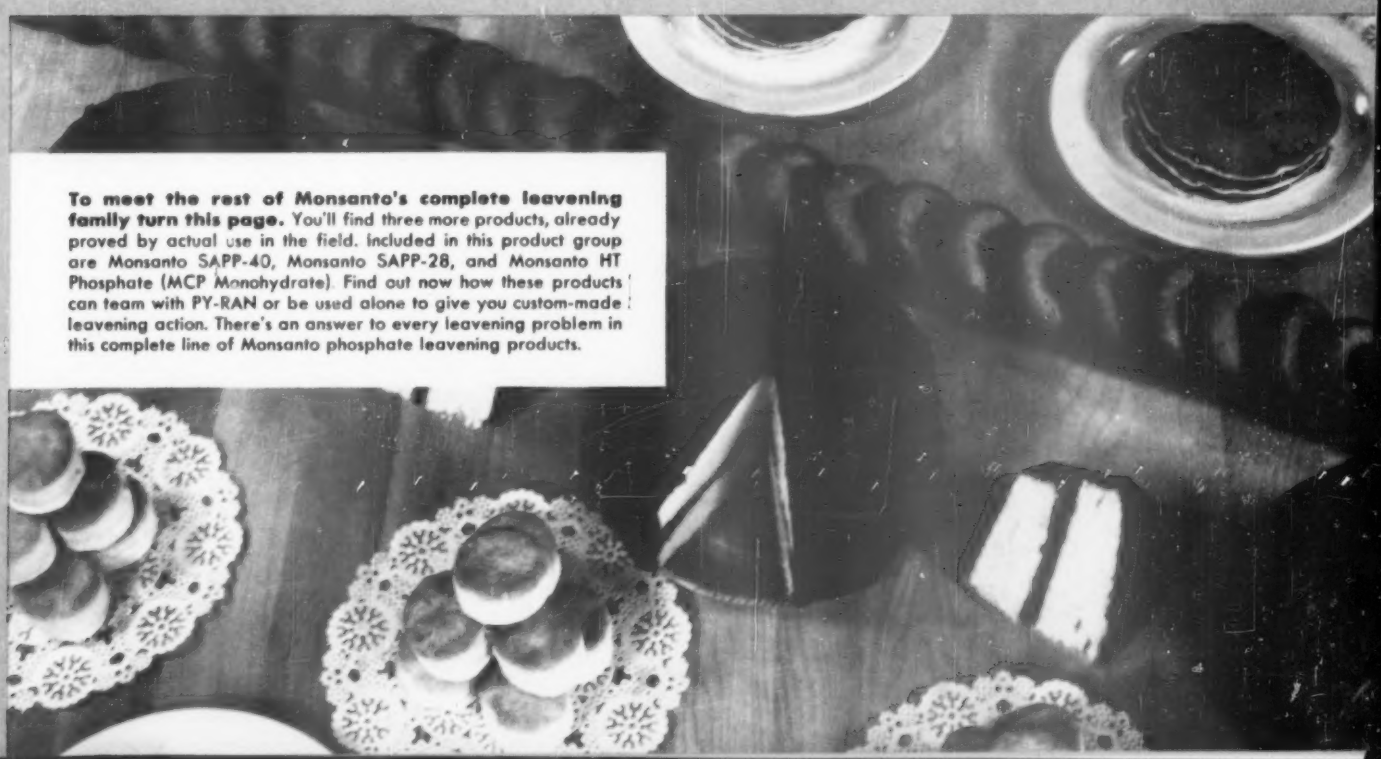
# TESTS PROVE PY-RAN GIVES SLOWER, CONTROLLED $CO_2$ RELEASE DURING CRITICAL FIRST 2 MINUTES OF MIXING

**PY-RAN'S greater stability means controlled release of gas even after long storage.** Tests clearly prove how PY-RAN releases $CO_2$ slowly during first two minutes after dough or batter has been made. This two-minute reading is especially important, as any $CO_2$ evolved prior to this time will be unavailable for leavening action in baked goods. PY-RAN holds this gas for release at the proper time—during baking.

A slow, controlled gas release as produced by PY-RAN minimizes tunneling, coarse texture and other troubles. A baked product is produced which has improved texture and a uniform, small-cell structure.

PY-RAN'S stability also adds increased tenderness. Baked goods are friable, no longer possess the toughness caused by poor, uncontrolled leavening.

Test this product for yourself and see how PY-RAN'S controlled $CO_2$ release can improve your prepared mixes and self-rising flour.



**To meet the rest of Monsanto's complete leavening family turn this page.** You'll find three more products, already proved by actual use in the field. Included in this product group are Monsanto SAPP-40, Monsanto SAPP-28, and Monsanto HT Phosphate (MCP Monohydrate). Find out now how these products can team with PY-RAN or be used alone to give you custom-made leavening action. There's an answer to every leavening problem in this complete line of Monsanto phosphate leavening products.

# There's an answer to every leavening problem in the complete family of Monsanto Phosphate Leavening Agents

If your Monsanto representative has not already given you details on PY-RAN, fill out coupon and we will see that you get immediate attention.

**Monsanto SAPP-40** . . . ideal for machine doughnut mixes. Gives a fine texture and crust. Reduces tunnels. Cuts down on grease absorption, improves doughnut's shape. Here is a product that gives uniform action—*every time.*

**Monsanto SAPP-28** . . . a slow-action baking acid, especially suited for cakes, biscuits, muffins. Has beneficial effect on gluten in flour; imparts greater extensibility and higher gas retention.

**Monsanto HT Phosphate** (MCP Monohydrate) . . . versatile, effective, contains no free phosphoric acid, hence does not attract moisture and cause premature reaction with soda. Use it alone or mix with other Monsanto leavening agents for good results.

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# *Annual Meeting Bulletin Board*

**IT'S THE BILTMORE, LOS ANGELES, JUNE 27-JULY 1, 1954!**

**Last Call for Abstracts!** Happy New Year! In case you have not sent in the abstract of your proposed Annual Meeting paper, please add as a belated resolution for the new year: "I hereby resolve not to keep the symposia leaders and the program chairman in further suspense and will therefore, today, prepare three copies of the abstract, giving my name, affiliation and the exact title of my paper as I wish it to appear in the program, and mail it—in ample time to beat the deadline, February 1, 1954—to the symposium leader concerned or to the program chairman." Consult the list below for the addresses of symposia leaders and the program chairman.

**Progress Report.** Response to the October 9 request for progress reports from each of the sixteen symposia leaders is reported by Dr. Arthur N. Prater, Program Chairman, as "very satisfactory"—93.75% of the sixteen had returned statements of progress by mid-November. It is too early at this writing to predict the exact number of papers that will be presented at each symposium, but several of the sessions have been extended to cover a full day—a healthy sign.

## The Program, the Leaders, and Progress Notes on the Sessions.

**PROBLEMS IN FRUIT AND VEGETABLE RESEARCH AND TECHNOLOGY**

PROFESSOR JOHN H. MACGILLIVRAY, Department of Vegetable Crops, University of California, Davis, California.

This program will include reports of maturity studies, plant breeding studies and raw material handling in processing plants. One-half day is planned.

**FLAVOR CHANGES IN FOODS AS INFLUENCED BY APPLIED CHEMICALS**

DR. CHARLES H. MAHONEY, National Canners Association, 1133 Twentieth Street, N. W., Washington 6, D. C.

Plans for this program are well under way for a one-half day symposium covering the important aspects of this topic.

**FOOD AND DRUG STANDARDS**

MR. CHARLES W. KAUFMAN, Kraft Foods Company, 500 Peshtigo Court, Chicago 90, Illinois.

A full day is planned, including speakers from industry, from Federal and State regulatory agencies, and from research institutions—insuring a thorough coverage of this very timely subject.

**CITRUS CONCENTRATES**

DR. W. R. ROY, Minute Maid Corporation, Plymouth, Florida.

A full day's program is being scheduled, covering practically every aspect of the citrus concentrate field.

**RECENT FUNDAMENTAL INVESTIGATIONS IN FOOD SCIENCE**

DR. AKSEL G. OLSEN, General Foods Corporation, Central Laboratories, 11th and Hudson Streets, Hoboken, New Jersey.

A full day's program has been planned for this symposium. The talks will be by experts in their various fields and will consist of broad discussions of various important general topics, rather than contributed research papers on specific subjects. Ample time will be allowed for discussion following each talk.

**MARKETING PROBLEMS**

MR. ROY H. WALTERS, General Foods Corporation, 250 Park Avenue, New York 17, New York.

A one-half day program is being planned, emphasizing the importance of marketing problems from the standpoint of the food technologist.

**CONSUMER TESTING**

DR. HELEN L. HANSON, Western Regional Research Laboratory, U. S. Department of Agriculture, Albany 6, California.

A one-half day program is being planned. If possible, the program will be limited to papers concerned with critical evaluation of methods rather than a presentation of the results of consumer tests. Papers giving actual experimental evidence of the influence of test conditions on the reliability of results will be welcomed and prospective speakers in this field are asked to write to Dr. Hanson with regard to the possible inclusion of their contribution in this program.

**SPECIAL PURPOSE FOODS**

DR. ERNEST GEIGER, 3842 Monteith Drive, Los Angeles 43, California.

This program will feature presentations of the scientific aspects of special dietary foods, and the importance of this rapidly developing field to the food technologist.

**SEAFOOD AND SEAFOOD PRODUCTS**

MR. KARL ENVOLDSEN, Envoldsen Shrimp, Inc., 1200 West Ninth Street, Cleveland 13, Ohio.

**WINE AND WINE-TASTING**

MR. HAROLD W. BERG, Department of Viticulture, University of California, Davis, California.

A one-half day session has been planned for this program. The technical aspects of wine and wine tasting will be stressed. The session will command the interest and attention of all food technologists interested in the wine industry and in the proper utilization of wines.

**FOOD ENGINEERING**

DR. CURTIS E. MAIER, Continental Can Company, Inc., 4645 West Grand Avenue, Chicago 39, Illinois.

A full day's program has been planned to cover the engineering aspects of the food industry. This program will be broad in nature and will consist of a thorough discussion of the various phases of food production and processing.

**WHAT'S NEW IN FOOD PACKAGING**

DR. KENNETH W. BRIGHTON, American Can Company, 11th Avenue and St. Charles Road, Maywood, Illinois.

A one-half day session has been arranged which will include rigid and non-rigid packaging materials, as well as considerations of the shipping containers.

**PECTIN AND PECTIC MATERIALS IN RELATION TO FOOD PROCESSING AND PRESERVATION**

DR. REESE H. VAUGHN, Department of Food Technology, University of California, Davis, California.

Dr. Vaughn, in cooperation with Dr. I. J. Hutchings, of the H. J. Heinz Company, Pittsburgh, Pennsylvania, is arranging this symposium to cover all aspects of this specific field. With the newer knowledge of the importance of pectin and pectic materials in the food industry, this program is a very timely one.

**FROZEN FOODS**

DR. K. G. DYKSTRA, Birds Eye Division, General Foods Corporation, 162 South Main Street, Albion, New York.

At this session, papers dealing with research in frozen food technology will be presented.

**ADVANCES IN FRUIT AND VEGETABLE DEHYDRATION**

DR. JOSEPH R. WAGNER, Quartermaster Food and Container Institute, 1819 West Pershing Road, Chicago, Illinois.

Following the very successful presentation of papers in the dehydration field at the Boston meeting, Dr. Wagner is arranging a symposium to include research reports of results obtained during the past year.

## ANNUAL MEETING BULLETIN BOARD

**ROUNDTABLE DISCUSSIONS**

Dr. M. L. Anson, Lever Brothers Research Center, Edgewater, New Jersey.

There is still time for interested groups to arrange for small meetings to discuss selected topics of a research nature. Those interested in arranging for a small, active discussion group should write to Dr. Anson so that arrangements may be made. These discussion gatherings, which are outside of the formal program, are in the nature of an experiment and recommendations for future programs will be based upon the results.

**GENERAL PAPERS**

Dr. Arthur N. Prater, Gentry Division, Consolidated Grocers Corporation, 837 North Spring Street, Los Angeles 12, California.

Several general papers have been received and it is anticipated that many more will be submitted. It should be noted that three copies of brief abstracts of any general papers must be in the hands of the general program chairman prior to the deadline of February 1, 1954.

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Again, it is pointed out that there are various committees of the Institute which should meet at the annual meeting. If these committees will make their desires known to the program chairman, a time and a place will be designated, provided the request is received by the program chairman at the time of the deadline, February 1, 1954. Insofar as possible, designate the size of the room desired, and if any time preference exists, please so indicate.

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**Special Program in Honor of Professor Edwin B. Hart.** A number of Professor Hart's former students and associates at the University of Wisconsin are arranging a special program in his honor.

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**Publicity Releases on Meeting Papers.** The industrial journals in the food field like to have an opportunity to read the complete text of meeting papers of interest to them immediately prior to the meetings in order to slant the material to their needs. Although complete papers will not, in any instance, be released to the press for publication *in toto*, there is no objection to the publication of abstracts or even somewhat fuller versions of the paper. In fact, such advance publicity in the industrial press prior to the official publication of the full paper in one of our own journals is usually desirable for the Institute as well as for the author and the firm or institution which he represents. It is therefore stressed that authors desiring wider notice of the work they are reporting at the meetings should have an extra copy of their paper available in the press room before or at the time of presentation. (As in the past, however, one complete copy of the paper must also be placed in the hands of the symposium leader at the close of the session in which the paper is delivered.)

**Special Breakfast and Luncheon Meetings.** All requests for special breakfasts and luncheons, together with date desired, time, and probable attendance should be sent at once to Mr. W. E. Baier, Research Department, Sunkist Growers, 616 East Grove Street, Ontario, California.

## Books

The Handbook of Solvents. Leopold Scheflan and Morris Jacobs. D. VanNostrand Company, Inc.

This book is divided into two major sections. The first section is a discussion of the theory of solvents and solvent action, and of the accepted practices in laboratory and plant handling of solvents. Considerable attention is given to the factors involved in safely using those solvents which are hazardous, both from physiological action and flammability.

The second section of this book is a tabulation of the physical constants of some 2700 organic liquids which might be used as solvents, including commercial grade materials as well as pure chemicals. The tabulation is according to the *Chemical Abstracts* nomenclature with a cross reference index of synonyms and common names.

The Handbook will probably be of greater value to those in industries where solvents are part of the product, as protective coatings, than to the Food Technologist, as the discussion section is slanted towards those applications. The tabulation of properties is useful as values from many sources are combined into one volume, facilitating comparisons and selection of the solvent or solvents best suited for a particular purpose.

Walter E. Moss,
Chicago.

Algal Culture From Laboratory to Pilot Plant. Ed., John S. Burlew. Carnegie Institution of Washington Publication 600, Washington, D. C., 1953. 357 pp.

Thomas B. Osborne's pioneer and classical work on the vegetable proteins was supported by the Carnegie Institution of Washington for more than 20 years starting in 1906. There are numerous other examples, including the present one, of research programs on fundamental biological problems aided or conducted by this outstanding organization.

The Carnegie Institution's investigations on the mass culture of algae are an "offshoot of its program of research on photosynthesis." After a preliminary analysis of the problem by H. A. Spoehr and H. W. Milner, reported in 1948 in the Carnegie Institution of Washington Yearbook No. 47, the engineering phases of the program were transferred to the Research Corporation of New York. Through collaboration the factors involved in the design of a pilot plant were studied by the Stanford Research Institute, the economic aspects of the subject were reviewed by the American Research and Development Corporation of Boston, and the large-scale production of algae was investigated by Arthur D. Little, Inc., of Cambridge, Massachusetts.

Simultaneously, the nutrition, growth, composition, and nutritional value of algae were studied by members of or investigators sponsored by the Institution. These workers included Jack Meyers (University of Texas), Robert W. Krauss (University of Maryland), A. W. Fisher, Jr. (Arthur D. Little, Inc.), W. J. McAleer (Merck and Company, Inc.), John W. Burlew (Carnegie Institution, Washington, D. C.) and H. A. Spoehr, H. W. Milner, J. H. C. Smith, B. Kok, E. A.

(Continued on page 18)

THE MOST ADVANCED FOOD PROCESSING LINES AVAILABLE TODAY
...Preserves the best in food flavor, color, texture and nutritive value

# fmc "Sterilmatic" PRESSURE COOKER and COOLER

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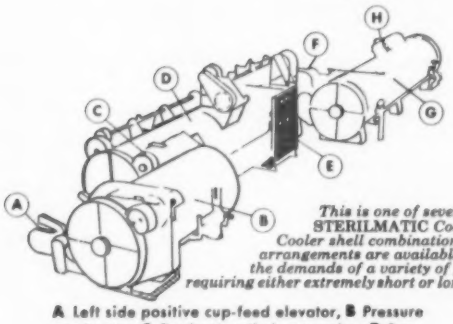


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High-speed *STERILMATIC* Cooker and Cooler lines give canners the *precise processing control* needed to maintain their high standard of product quality and uniformity. This continuous, automatic equipment cooks every can *evenly*—cooks every can *exactly alike.* The natural flavor, color, texture and essential vitamins of farm-fresh fruits and vegetables are protected and preserved at their peak of harvest perfection. And these qualities last, too—locked in to be fully enjoyed when the can is opened and the product served. Write for full information on FMC's outstanding "one-man cook room," or call your nearest FMC representative.

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## BOOKS

(Continued from page 16)

Davis, J. Dedrick and C. S. French (all of the Carnegie Institution, Stanford, California).

Nearly one-third of the monograph consists of reports of similar studies by workers in foreign countries. These investigators were E. C. Wassink (and collaborators) of the Agricultural University, Wageningen, Netherlands; H. Tamiya (and collaborators) of the University of Tokyo, Tokyo, Japan; H. von Witsch and R. Harder of the University of Göttingen, Göttingen, Germany; F. Gummert (and collaborators) of Kohlenstoffbiologische Forschungsstation E. V., Essen- Bredeney, Germany; G. E. Fogg and D. M. Collyer of University College, London, England; M. J. Geoghegan of Imperial Chemical Industries Limited, Berkshire, England; J. Jorgensen and J. Convit of Leprocomio de Cabo Blanco, Maiquetia, D. F., Venezuela; and M. Evenari (and collaborators) of the Hebrew University, Jerusalem, Israel.

The unicellular alga, *Chlorella pyrenoidosa,* was employed for most of the investigations reported in the present monograph although other species were studied including *Chlorella ellipsoides, Chlorella vulgaris, Scenedesmus bijugatus* and *Scenedesmus obliquus.*

Various types of laboratory and pilot plant equipment utilized in the mass-culture experiments are illustrated by 6 photographs or diagrams in Chapter 9, 9 in Chapter 17, and 5 in Chapter 18. Complete data are reported by Arthur D. Little, Inc., on the construction and operation of large-scale culture units, culture conditions, harvesting and yields of Chlorella, analytical procedures and other critical problems.

The major nutrient was carbon dioxide-enriched air. The nutrient solutions contained ions (expressed as p.p.m.) as follows: $SO_4$ S 1940, $H_2PO_4$ S 1780, K 1690, $NO_3^-$ 1530, Mg 492, B 0.5, Mn 0.5, Zn 0.05, Cu 0.02, Mo 0.01 and Fe 0.01.

The over-all average yield of dry algae for 52 days of plant operation was approximately 2 g. per square meter per day and the maximum yield for a 10-day period was 11 g./($m^2$)/(day). In order to approach the yield of 110 g./($m^2$)/(day) estimated to be theoretically possible with complete utilization of the visible spectrum, it was deemed necessary to culture algae in regions with the highest percentage of sunlight, employ fast-growing strains of algae, and provide optimum nutrient and temperature conditions. Yields of 20 g./($m^2$)/(day) would be equivalent to 17.5 tons/(acre)/(year). On this basis, less than one million acres would be required for algal culture to supply half the per capita need of 65 g. of protein a day for the present world population.

Advantages in culturing algae, contrasted to higher plants, as the main source of food, are that the former are more efficient photosynthesizers, can be grown almost continuously at constant optimum rate, and require only light and a simple growth medium (water, carbon dioxide and inorganic salts) for the production of organic material consisting mainly of proteins, lipids and carbohydrates. The deposition of lipids consisting of the triglycerides of stearic, oleic and other fatty acids may be increased from 40% to 70% of the dry weight of the algae by maintaining low concentrations of available nitrogen in the nutrient solutions. Starch and sucrose have been isolated from *Chlorella pyrenoidosa,* other classes of carbohydrates from *Scendesmus obliquus,* and the sterols ergosterol, zymosterol and chondrillasterol from different algal sources. The protein content of algae may vary from 10% to more than 60% depending upon the experimental conditions but the nature of these proteins is unknown. The relative quantities of 23 amino acids identified in 3 algal strains are tabulated in Chapter 19 and quantitative data for 11 amino acids in Chapter 20.

Direct tests on nutritional quality include the successful feeding of "plankton soup"—containing as much as 70 g. dry weight of microorganisms (largely algae) per liter—to patients in a leper colony and reasonable growth of rats and chicks on diets containing dried algae as the sole source or part of the protein. Schieler *et al.* [Food Research, **18**, 377 (1953)] have concluded from the published data that "Chlorella protein, and possibly cells, may serve satisfactorily as a source of amino acids in animal feeding and, if supplemented with cystine, methionine and histidine, would be equivalent to other proteins of high nutritional quality." Fisher and Burlew (Chapter 20) have presented data on the vitamin content of Chlorella and have concluded that

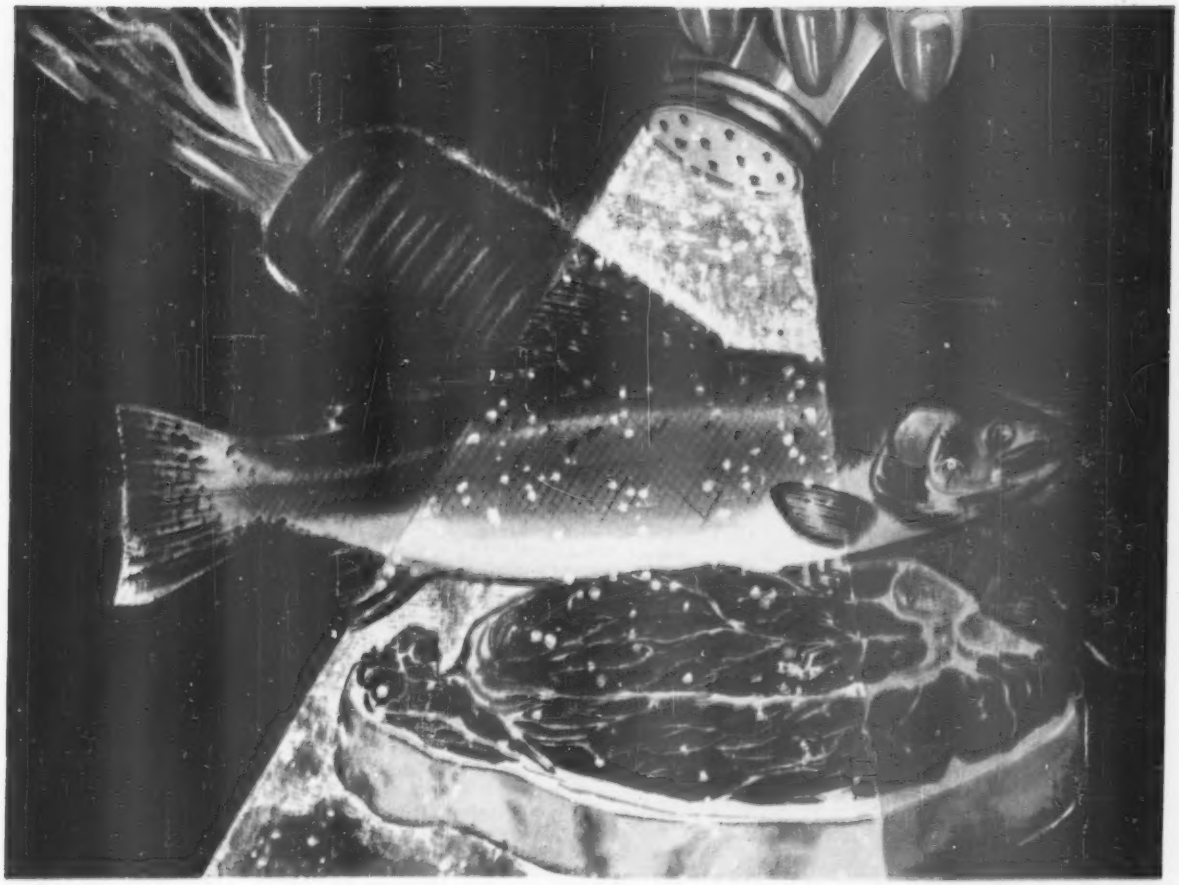
(Continued on page 20)

## Obituary

Members of the Institute of Food Technologists were saddened by the sudden passing of Orville G. Hankins of 2704 Brentwood Road, N. E., Washington, D. C., on November 13, 1953. A veteran of more than 33 years' service in the Animal Husbandry Division of the Bureau of Animal Industry, Mr. Hankins was head of the Meats Division of Animal and Poultry Husbandry Research of the Agricultural Research Service, with his headquarters at the Agricultural Research Center, Beltsville, Maryland. He has served the Institute in many capacities—among them as an associate editor of FOOD TECHNOLOGY. A native of Decatur, Illinois, Mr. Hankins was a graduate in Animal Husbandry of the University of Illinois. Following graduation he taught agriculture at Louisiana Polytechnic Institute, Ruston, Louisiana. He then served as swine extension specialist for the University of Kentucky at Lexington, Kentucky, for several years, joining the Animal Husbandry Division of the Bureau of Animal Industry in 1920.

Mr. Hankins was a nationally known research authority on factors contributing to the quality and palatability of meat and worked tirelessly to develop methods for improving the meat supply of the nation. During World War II Mr. Hankins directed the extensive research which developed methods of dehydrating meat which formed the basis for the successful use of meat in field rations for the United States Armed Forces throughout the world.

Mr. Hankins is survived by his widow, Mrs. Ethel B. Hankins, and by his son, Robert B. Hankins, a member of the legal staff of Capital Airlines.



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## BOOKS

(Continued from page 18)

"dried Chlorella could be an important source of vitamins in the diet of human beings." There is need for additional investigations on the nutritional value of algae.

The potentialities of algae as industrial raw materials for the production of proteins, lipids, carbohydrates, pigments, vitamins and antibiotics have been discussed briefly in Chapter 21 and of sterols in Chapter 22.

It was the general conclusion that algae potentially are suitable for large-scale production and world-wide consumption as foods. This monograph is written in good style and is well printed. It contains a complete, authoritative account of laboratory and pilot plant studies on the nutrition, culturing, harvesting, yields, composition and nutritional qualities of *Chlorella pyrenoidosa* and other algae.

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## FUTURE DATES FOR FOOD TECHNOLOGISTS

| | |
|---|---|
| **1954** | |
| January 18-20 | National Potato Chip Institute, Cincinnati, Ohio |
| January 22 | National Poultry and Egg Board Meeting, Chicago, Illinois |
| January 22 | Annual Meeting of the National Wooden Box Association, Chicago, Illinois |
| January 31-February 1 | Meeting of the American Dehydrators Association, New Orleans, Louisiana |
| February 1954 | Annual Meeting of the National Soup Mix Association, Chicago, Illinois |
| February 1-4 | Frozen Food Industry Convention and Exhibition, New York, New York |
| April 22-23 | National Meeting of the American Dry Milk Institute, Cleveland, Ohio |
| April 27-28 | Annual Meeting of the National Cheese Institute, Chicago, Ill. |
| May 2-5 | Annual Meeting of the National Fisheries Institute, Cleveland, Ohio |
| May 23-26 | Flavoring Extract Manufacturers' Association, New York, N. Y. |
| May 26 | Fruit and Syrup Manufacturers' Association, New York, N. Y. |
| *May 26-28* | *Fourth Annual Convention, Australian Regional Sections, Institute of Food Technologists, Leura, New South Wales, Australia.* |
| June 23-25 | Seventh Annual Meeting of the Research and Development Associates, Food and Container Institute, Los Angeles, California |
| **June 27 to July 1, 1954** | **Fourteenth Annual Meeting of the Institute of Food Technologists, Los Angeles, California** |

(Information concerning future dates of national and international meetings, conventions and exhibits of interest to food technologists should be sent to the editorial office.)

# Selected Abstracts*

## ANALYTICAL METHODS

**A new reagent for the titration of water.**

BELCHER, R., AND WEST, T. S. *J. Chem. Soc.*, 1772-6 (1953).

A new reagent for the detn. of water in inert org. solvents consists of a soln. of $SO_2$ and $Br_2$ in $CHCl_3$. It is used similarly to the conventional Karl Fischer reagent. The results obtained from the new reagent are more nearly stoichiometric than those given by the Karl Fischer reagent, and it appears to be more stable. The change in redox potential at the endpoint of the titration is very sharply defined, and a visual endpoint depending on the disappearance of the color of bromine from soln. is as satisfactory as the potentiometric endpoint. The reagent is cheaper. Its main disadvantage is that alcs. interfere with the detn. of water, but in most cases where a preliminary extn. of moisture is necessary, alc. can be replaced by dioxan.

**Potentiometric iodine titration of branched starch fractions.**

FOSTER, J. F., AND SMITH, R. L. Iowa State Coll. *J. Sci.*, *27*, 467-77 (1953).

A differential null-point titration procedure for the study of iodine binding by amylose and amylopectin at relatively high iodine levels (above 0.001 *M*) is described. The method, although suitable for routine measurements, yields results on various amylopectins which are in substantial agreement with those using a more precise but much more cumbersome method. Typical results are presented for the whole starches from potato, corn, and tapioca and for the corresponding amylose and amylopectin fractions and the limit dextrins. Results are also presented on waxy maize starch and its limit dextrin, and on glycogen. Binding by the limit dextrins is at least as strong, in the early stages of binding, as in the case of the parent amylopectins. The possible significance of this result in terms of the binding mechanism is discussed.

**The chromatographic examination of permissible food dyes.**

ANDERSON, J. R. A., AND MARTIN, E. C. *Anal. Chim. Acta*, *8*, 530-7 (1953).

The $R_f$ values of 36 permissible food dyes were detd. by partition chromatography on filter paper. The detection of these colors in jelly crystals was investigated and a method for their extn. and development is described. A relationship between dye structure $R_f$ value is suggested.

**A new method for assay of "pyrethrins."**

MITCHELL, W. *J. Sci. Food Agr.*, *4*, 278-82 (1953).

A new method for assay of "pyrethrins" is described. It is suggested that its successful operation requires less experience than do the existing methods. Comparative results on pyrethrum flowers and exts. by the new method and the A. O. A. C. method are given. A comment is made on the standard of accuracy to be expected from pyrethrum analyses in general. An app. for the extn. of pyrethrum flowers is described and illustrated.

**A new method for continuous viscosity measurement. General theory of the ultra-viscoson.**

ROTH, W., AND RICH, S. R. *J. Appl. Phys.*, *24*, 940-50 (1953).

A new continuous ultrasonic viscometer employing a pulsed resonant exponentially damped magnetostrictive strip is described and treated theoretically. Properties of viscoelastic materials affecting the propagation of transverse elastic waves are derived and are related to the response of the viscometer. Typical applications of the use of the ultrasonic viscometer are presented.

* These Selected Abstracts are made available to FOOD TECHNOLOGY through the cooperation of Associate Editor H. A. Campbell and the General Foods Corporation of New York, N. Y. The abbreviations found in these abstracts are similar to those used by Chemical Abstracts.

(Continued on page 22)

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## SELECTED ABSTRACTS

(Continued from page 20)

**An apparatus for the rapid determination of freezing point diagrams.**

BURKHART, L. A., MOORE, D. W., AND MCEWAN, W. S. *Rev. Sci. Instr., 24,* 461 (1953).

With this app., binary systems contg. a simple eutectic have been completed in less than a day. The setup is easily used and cleaned and seven detns. may be run simultaneously.

## BIOLOGICAL SCIENCES

### BIOCHEMISTRY

**The composition of the adult human body as determined by chemical analysis.**

FORBES, R. M., COOPER, A. R., AND MITCHELL, H. H. *J. Biol. Chem., 203,* 359-66 (1953).

The chem. compn. of the body of a normal adult human, 46 years of age, is reported. The whole body contained 19.44% ether ext., 55.13% moisture, 18.62% protein, 5.43% ash, 1.907% calcium, and 0.925% phosphorus. Analyses are reported on 13 separate tissues and organs.

**Paper chromatography of the 3-phenyl-2-thiohydantoin derivatives of amino acids with application to end group and sequence studies.**

LANDMANN, W. A., DRAKE, M. P., AND DILLAHA, J. *J. Am. Chem. Soc., 75,* 3638-40 (1953).

A paper chromatographic method for identifying *per se* the 3-phenyl-2-thiohydantoin derivs. of amino acids is presented, by which N-terminal residues and amino acid sequences of peptides and proteins may be detd. conveniently.

**Biosynthesis of proteins.**

CAMPBELL, P. N., AND WORK, T. S. *Nature, 171,* 997-1001 (1953).

A review of recent work in the field of biosynthesis, including a critical evaluation of transpeptidation and the template theory as mechanisms for protein synthesis *in vivo.* 60 references.

**The template theory and the role of transpeptidation in protein biosynthesis.**

DALGLIESH, C. E. *Nature, 171,* 1027-8 (1953).

The synthesis of protein occurs without detectable evidence of free peptide intermediates. It is postulated that amino acids become attached to a nucleotide "template" and that as the residues link together, the growing peptide chain "peels" off leaving room for another protein mol. to form. Hence, many protein mols. may be synthesized simultaneously, each being at a different stage of "peeling."

**Degradation of methionine by hydrogen peroxide.**

MATSUO, Y. *Nature, 171,* 1021-2 (1953).

Degradation of methionine with $H_2O_2$ resulted in the formation of methionine sulfoxide, methionine sulfone, α-amino butyric acid, alanine or homoserine, glycine, aspartic acid and cysteic acid. A possible pathway for degradation of methionine on the basis of these results is postulated.

### MICROBIOLOGY

**Microchemical methods for the characterization of bacteria.**

COWAN, S. T. *Chemistry & Industry,* 883-6 (1953).

Some of the reasons for discrepant results in biochem. tests are indicated. The micromethods developed go some way to simplifying biochem. tests; once the organism has been grown on a suitable medium, contg., if necessary, any special growth factors, the suspension is made and added to a series of solns. of known chem. constitution, each of which can be duplicated at will. Furthermore, in the microtests one enzyme system is tested at one time, an advantage a growing culture can never enjoy. The microtests so far only touch the fringe of a large subject; it should be possible to characterize a bacterium by its enzymic formula in a manner analogous to the serologist's characterization by antigenic formula. Many more tests need to be developed, and not only tests for end-products. The microtests should be readily adaptable to studies on the availability of different amino acids.

**Methodology for isolating Salmonella from dried egg products.**

AYRES, J. C. *Iowa State Coll. J. Sci., 27,* 479-89 (1953).

Qual. and quant. tests are described. 42 references.

**Inactivation of vaccinia virus by a diffusible component from hydrolyzed hyaluronic acid.**

MCCREA, J. F., AND DURAN-REYNALS, F. *Science, 118,* 93-5 (1953).

The component of a hyaluronic acid soln. which inactivates vaccinia virus grown in cell culture is, in all probability, glucuronic acid or a glucuronide.

### NUTRITION

**The effect of heat on the nutritive value of milk proteins as influenced by water and fat.**

SCHROEDER, L. J., IACOBELLIS, M., LEES, H., AND SMITH, A. H. *J. Nutrition, 50,* 351-60 (1953).

Tests on adult dogs have shown that autoclaving non-fat dry milk solids results in a decrease in the digestibility and nutritive index of the milk proteins. In reconstituted milks, the presence of $H_2O$ markedly inhibits the reaction between carbohydrates and protein. The results of *in vitro* expts. on the heating of dried skim milk and whole milk powder reconstituted with $H_2O$ show an increased rate of proteolysis of the milk protein by cryst. enzymes. The fat present exerts a min. effect. It may be concluded that the heating of milk proteins in an aq. medium does not decrease the nutritive value of the protein constituents; on the contrary, heat treatment under these conditions appears to enhance the rate of *in vitro* proteolysis.

**Protein efficiency. Improvement in whole yellow corn with lysine, tryptophan, and threonine.**

SURE, B. *J. Agr. Food Chem., 1,* 626-9 (1953).

As threonine was found to improve the proteins in polished rice and in milled and whole wheat, its effect on the proteins in whole yellow corn was investigated. Marked improvement in the efficiency of the proteins in two types of Guatemala whole yellow corn was secured by the addn. of 0.5% threonine in the rations in the presence of lysine and tryptophan. However, a supplementary effect of threonine to the proteins in U. S. hybrid whole yellow corn was obtained only in the presence of lysine, tryptophan, and methionine.

**Time factors in the utilization of a mixture of amino acids (protein hydrolysate) and dextrose given intravenously.**

ELMAN, R. *J. Clin. Nutrition, 1,* 287-94 (1953).

The existence of two time factors in the metabolism of amino acids given intravenously is shown by N balance studies in 4 patients given infusions of an inadequate caloric mixt. of glucose and amino acids, each patient serving as his own control. The findings indicate a greater utilization of amino acids (1) when glucose was infused at the same time, and (2) when the mixt. was infused at a slower rate. These findings confirm observations made by others in humans and in animals with oral feeding.

**The influence of protein and certain amino acids, particularly threonine, on the deposition of fat in the liver of the rat.**

HARPER, A. E., MONSON, W. J., BENTON, D. A., AND ELVEHJEM, C. A. *J. Nutrition, 50,* 383-93 (1953).

## SELECTED ABSTRACTS

The influence of protein (gelatin and addnl. casein), threonine, glycine, serine, glycocyamine, choline and betaine on the deposition of fat in the livers of rats fed 9% casein-sucrose rations contg. adequate choline, methionine, inositol and vitamin $B_{12}$ was studied. 6% gelatin, 2% casein or 0.18% DL-threonine were each effective in reducing the accumulation of liver fat observed in animals receiving the basal ration. The other compds. listed reduced the accumulation of liver fat to a lesser extent under these conditions. The possibility that enzymes concerned with fat metabolism might have been limiting in animals receiving the basal ration is discussed, as is also the suggestion that some of these substances may participate more directly in fat metabolism. No satisfactory explanation of the results can be proposed as yet.

**Some factors affecting the growth and development of rats fed rancid fat.**

GREENBERG, S. M., AND FRAZER, A. C. *J. Nutrition, 50,* 421-40 (1953).

Rancid fat in the diet increases the protein requirement of the rat for optimum growth. A diet contg. 10% rancid soybean oil (peroxide no. 530-550 $\mu$ moles/g.) supported almost normal growth in rats when all known essential nutrients were supplied in large amts. and protein constituted 30% of the diet. The difference in growth between a group of rats fed rancid fat with an optimum level of all other known nutrients and a group fed an equiv. fresh fat diet can be accounted for in the main by the lowered consumption of the rancid fat diets during the first days of the exptl. period. The only organ wt. seriously affected by the presence of the rancid fat was that of the intestinal tract.

**The use of oral high fat, high calorie emulsion for total feeding.**

KUHL, W. J., GROSSMAN, M. I., AND CONSOLAZIO, C. F. *J. Clin. Nutrition, 1,* 218-23 (1953).

A high cal. liquid diet, consisting primarily of a 40% fat emulsion was administered as the sole source of feeding to six patients with fracture of the mandible. While ingesting 400 g. of fat, 70 g. of protein, and 122 g. of carbohydrate, an increase in wt. and marked pos. N balance was noted in all subjects. Fecal fat excretion increased 7.68 g. above the control level as a max. No consistent changes occurred in fasting blood levels of total or neutral fat, phospho-lipid, cholesterol, serum total protein or A/G ratio, N. P. N., fasting blood sugar, or $CO_2$ content.

**Effect of different starches on the choice of diet by rats.**

TRIBE, D. E., AND GORDON, J. G. *Brit. J. Nutrition, 7,* 202-7 (1953).

Animals allowed to choose between a palatable diet, deficient in the vitamin B complex, and an unpalatable diet, producing refection, all died, presumably because they did not select a sufficient amt. of the diet permitting refection. Animals allowed to choose between two palatable dicts, both deficient in the vitamin B complex, chose equal quantities of both. Rats allowed to choose between a palatable diet, deficient in vitamin B complex, an unpalatable diet producing refection and a palatable and completely adequate diet, all chose the palatable and adequate diet.

**Further evidence for an unidentified hatchability factor in condensed fish solubles.**

ARSCOTT, G. H., AND COMBS, G. F. *Poultry Sci., 32,* 730-3 (1953).

Evidence is presented for the presence of an unidentified dietary essential in condensed fish sols. which is required for normal hatchability of fertile eggs by New Hampshire pullets fed a practical type ration contg. adequate amts. of known nutrients including vitamin $B_{12}$. Differences in hatchability were noted with pullets housed on wire floors and on litter. The improvement in hatchability observed with rations contg. fish sols. was more pronounced in pullets housed on wire floors, as compared with those maintained on litter, indicating that the incidence of coprophagy may greatly influence the amt. of the factor required in the ration.

**Growth stimulation by coconut milk.**

*Nutrition Revs., 11,* 180-1 (1953).

The coconut milk growth factor appears to consist of a no. of substances, closely related, but of unknown identity. Coconut milk has been shown to stimulate the growth of fungi, bacteria and orchids as well as of the cells in carrot and beet.

### PHYSIOLOGY AND MEDICINE

**The present status of plasma expanders.**

HARTMAN, F. W., AND BEHRMANN, V. G. *J. Am. Med. Assoc., 152,* 1116-20 (1953).

The gelatins are the most promising class of substances used for this purpose. The emergency use of dextran and polyvinylpyrrolidone in limited quantities are well as gelatin is justified in the treatment of shock states.

**The present status of liver function tests.**

LICHTMAN, S. S. *Current Med. Digest, 20,* 31-3, August, 1953.

The results of liver function tests were correlated with morphologic changes observed with the assistance of aspiration liver biopsies. The tech. advances include bilirubin fractionation employing the photoelec. colorimeter, and more accurate plasma protein fractionation. The blood serum plasma (BSP) retention test using 5 mg. per kilo and estn. at 45 mins., has evolved highly dependable and useful. The liver function tests play an indispensable role in screening industrial applicants, blood donors for subclinical liver disease, and in evaluating the toxicity of pharmaceutical agents before clinical release.

**Sodium as a toxic ion in potassium deficiency.**

CANNON, P. R., FRAZIER, L. E., AND HUGHES, R. H. *Metabolism, Clin. and Exptl., 2,* 297-312 (1953).

The myocardial lesions that develop in protein-depleted rats subjected to protein repletion by diets devoid of potassium become more severe as the intake of dietary sodium is increased. Sodium chloride becomes quickly and lethally toxic in such animals in the presence of severe potassium depletion.

### ENGINEERING AND PLANT EQUIPMENT

**Philosophy of pilot plants.**

*Ind. Eng. Chem., 45,* 1619-28 (1953).

A symposium contg. the following papers: Introduction, Brown, C. L. (1619); Pilot plants in the petroleum refining industry, Blatz, L. S. (1620); General philosophy of pilot plants, Payne, J. W. (1621-2); An approach to pilot plant studies, Maerker, J. B., and Scholl, S. W. (1622-5); Basic factors in pilot plant work, Conn., A. L. (1625-8).

**Factors influencing the properties of spray dried materials.**

DUFFIE, J. A., AND MARSHALL, W. R. *Chem. Eng. Progr., 49,* 417-26 (1953).

A vertical, cylindrical concurrent-flow spray dryer, 8 in. in diam. and 20 ft. high, was developed for exptl. studies on the drying of a stream of drops of controlled size. A viscous-jet atomizer was used to produce the drops, and its breakup characteristics in this application were studied. The bulk ds. of several materials were studied as a function of air and feed temps., feed concn., and material properties. Thirteen materials were spray dried, including inorg. salts, a dyestuff, a dispersing agent, whole milk, gelatin, coffee ext., and corn syrup. Photomicrographs of some of the products are shown.

(Continued on page 25 following technical papers)

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# The Influence of Salt and Temperature on the Microflora of Sauerkraut Fermentation[a,b]

CARL S. PEDERSON AND MARGARET N. ALBURY
*New York State Agricultural Experiment Station, Cornell University, Geneva, New York*

(Manuscript received June 23, 1953)

**It is shown that salt content and temperature of fermenting sauerkraut influence bacterial flora and also affect the quality and chemical composition of the product. The suppression or favoring influences of different salt contents and temperatures are related to various heterofermentative and homofermentative types of organisms. Sauerkrauts fermented with high salt concentrations or at high temperatures were found to be poor in color, flavor, and texture.**

In complex fermentations involving several types of organisms the relative influence of each bacterial type will depend on factors affecting its comparative growth. Salt content and temperature of the shredded cabbage and fermenting sauerkraut are the most variable factors in such fermentations under commercial conditions. Little attempt is made to control temperature. Despite efforts of the packers considerable variation in salt content is obtained in different parts of the vat. Since quality of sauerkraut produced under apparently similar conditions may vary, it seemed advisable to study the effect of different salt concentrations and temperatures upon the bacterial flora, chemical changes, and quality of the cured product.

Little attention has been given to the effect of temperature on the fermentation of sauerkraut. Parmele *et al. (5)* and Marten *et al. (4)* have observed that a better quality resulted when fermentation was carried out below 70° F. (21.1° C.), Le Fevre *(3)* suggested fermenting sauerkraut at temperatures above 80° F. (26.6° C.) since the lactic acid bacteria he studied grew more rapidly at such temperatures. Pederson *(8)* observed a close relationship between atmospheric temperatures and the rate of fermentation.

The effect of salt is possibly more obvious than the effect of temperature since high salt content sauerkrauts are subject to discoloring, while low salt will result in softening.

Brunkow *et al. (1)*, and Fred and Peterson *(2)* noted in sauerkraut the occurrence of pink areas which they attributed to the growth of yeasts where the salt content was higher than normal. Pederson and Kelly *(6)* noted that the growth of pink yeast was favored by any factor which tends to inhibit or retard the normal sequence of bacetrial growth. High salt, however, was the most common factor involved. Pederson *(9, 10)* related texture and quality differences to extremes in salt content. In the last paper *(10)* the difficulties of equal distribution under commercial conditions were pointed out.

This study, conducted over a four-year period, was primarily concerned with the changes in bacterial flora at different temperatures and at different salt concentrations. Differences in quality were so obvious that this became one of the more important observations.

## EXPERIMENTAL

The experiments were conducted with sauerkraut packed in one-gallon containers in order that the temperature and salt could be controlled more readily. For each experiment, a large lot of shredded cabbage was obtained from a commercial company. Sufficient cabbage was obtained so that several containers could be packed for fermentation at each temperature and at each salt level. The cabbage was thoroughly mixed with the required amount of salt and then packed into the containers. The containers were heated or cooled by water bath to bring the contents to one of the following temperatures of fermentation, 7.5°, 18°, 23°, 32° and 37° C. (45.5°, 64.4°, 73.4°, 89.6°, 98.6 F.). When the temperature was attained, the containers were placed in incubators operated at the selected temperatures. During the early fermentation some juice was forced out of the containers due to the production of carbon dioxide. These containers were kept filled at all times by adding sauerkraut of the same lot packed in quart jars.

During fermentation, samples were removed at intervals for the determination of total acid, pH and numbers of organisms, and for the isolation of pure cultures. Plates were prepared from suitable dilutions of the brine using a tryptone glucose yeast extract agar. Plates were incubated at 32° C. (89.6° F.) for 48 hours and then counted. From each plating 20 colonies were selected for isolation and later identification. Thus 200 or more cultures were obtained from each individual lot during fermentation.

The methods of identification were similar to those used in previous work, Pederson and Albury *(7)*. In general, about 80% of the cultures could be identified by the quick methods described. The others were usually attenuated types, many of which could be induced to produce typical reactions for the species after serial transfer.

## RESULTS AND DISCUSSION

**The effect of salt.** The results of the four-year study of the effect of salt on fermentation showed a general consistency with some variation in detail. The results for 1951 summarized, Table 1, showed that the fermentation regardless of salt content was always started by the species *Leuconostoc mesenteroides* and completed by the species *Lactobacillus plantarum* usually in conjunction with *Lactobacillus brevis*.

Salt concentrations of 3.5% inhibited growth in that total counts were considerably lower than those obtained at 2.25 and 1.0% salt. Highest counts were obtained from 1.0% salt sauerkraut.

The lower salt contents of 1.0 and 2.25% favored the development of the heterofermentative species *L. mesenteroides* and *L. brevis*. The leuconostoc persisted to a higher total acidity development particularly in the 1.0% salt sauerkraut. The highest salt, 3.5%, retarded the extent of development of all species but particularly

[a] Journal paper No. 930, New York Agricultural Experiment Station, Cornell University Geneva, New York, June 18, 1953.

[b] Presented before the Thirteenth Annual Meeting of the Institute of Food Technologists, Boston, Massachusetts, June 23, 1953.

prevented the development of *L. brevis*. In 3.5% salt sauerkrauts, only small numbers of strains of *L. brevis* were isolated in 1949 and 1951; in 1950 no strains were isolated. In all of the studies conducted, this was one of the few instances in which the species was not isolated at some stage during fermentation. It was also observed that the leuconostoc were suppressed at a lower acidity, whenever 3.5% concentrations were used.

The streptococci played a minor role in these fermentations regardless of salt content. The occurrence of strains of *Pediococcus cerevisiae* was somewhat erratic. Cultures of the species were never isolated in the 1947 and 1949 series nor from low salt sauerkrauts in 1950 and 1951. However, they were isolated in 1950 from the 3.5% salt sauerkraut and in 1951, the species played an important role in the fermentation with 3.5% salt. They were also obtained in the 2.25% salted sauerkraut that year.

In the 1949 series, results were somewhat atypical in that, unlike the normal fermentations in which leuconostoc predominated during the early stages of fermentation, attenuated or low acid producing strains of *L. plantarum* were isolated in greater numbers than *L. mesenteroides* during the early fermentation in the 3.5 and 2.25% salt concentration and were almost as predominant in the 1.0% salt concentration. They played a major role through the eighth day of fermentation. It was also true that great numbers of strains of *L. plantarum* were isolated in the temperature series in 1949 and at all temperatures except 7.5° C. (45.5° F.).

A further interesting correlation was noted in regard to the pH acidity relationship, indicating that growth of the heterofermentative species was suppressed in the higher salt. Final pH readings in 1949 and 1950 in 3.5% salt were 3.31 and 3.46, at acidities of 1.96 and 1.58% acid, respectively (Figure 1). These were lower

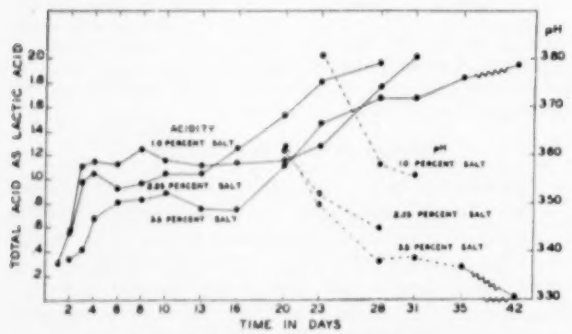


**Figure 1. The effect of salt upon the development of acid and changes in pH in krauts packed in 1949.**

pH values with lower acidities than attained in the 2.25 and 1.0% salt sauerkraut. In 2.25% salt sauerkraut the final pH attained was 3.46 and 3.48 with acidities of 2.02 and 1.63%, respectively, and in 1.0% sauerkraut final pH attained was 3.53 and 3.61 with acidities of 2.18 and 1.74% acid, respectively. Similar results were obtained in 1951 (Table 1).

The apparent inconsistant relationship between total acid and pH (Figure 1) has been observed not only in these studies but in previous ones and in similar studies with fermenting cucumbers. As previously stated, the lower salt content favored the development of the heterofermentative species. The 1% salt sauerkraut was most nearly a heterofermentation (Table 1). In contrast, the 3.5% salt sauerkraut was most nearly a homofermentation in that the growth of heterofermentative leuconostoc and lactobacilli was curtailed. The inconsistency then may be due in part to the relative amount of volatile acid produced by the heterofermentative species. Acetic acid, the major component of the volatile acid, is not so highly dissociated as lactic acid and thus produces less change in pH than lactic acid, Pederson and Bagg *(12)*. Although the total amount of lactic acid produced in some of the heterofermentations surpassed that produced in the simultaneously run homofermentations, the pH was not so low. Comparative dissociation however, cannot completely account for differences observed in the pH, acidity relationships. In pure homofermentations in which *L. plantarum* has been used as an inoculum, acidity and pH changes are very rapid, and relatively speaking a low pH and low total acidity are produced. At the same time, a smaller amount of growth occurs than in a fermentation which involves the 2 heterofermentative species followed by the homofermentative species. In the latter case, a greater total acidity is produced because there is less change in pH as compared with a strict homofermentation. Since there is a greater amount of growth in the heterofermentations, considerably more sugar must be fermented to produce a total acidity equal to that produced in the homofermentation. Therefore one might assume that a greater activity occurs with regard to other nutritive substances including minerals. Since more of such nutrients are brought into solution with increased growth activity, it seems logical that the greater amounts of amino acids and minerals, particularly phosphates, liberated in the heterofermentation may produce a greater buffering effect.

Regardless of the cause for increased buffering effect, there is little doubt of its beneficial effect on vegetable fermentation. In fermentations simultaneously run, the more highly buffered fermentations invariably have produced the better quality product. The results of earlier studies (Table 2) also showed a decreasing total acidity and volatile acidity with increased salt concentration beginning at about 2.25% salt. This was further indication of suppression of growth of heterofermentative lactic acid bacteria in higher salt concentrations.

There were marked differences between the sauerkraut samples during all 3 years from a quality viewpoint. Each year the high salt sauerkraut had the typical salty, bitter, somewhat stale flavor of oversalted kraut, and in addition had poor color, sometimes pink. Hunter color difference meter (a) readings taken only upon 1951 samples yielded figures of +1.8, —0.1 and —1.2 for the sauerkraut salted at 3.5, 2.25 and 1.0%, respectively, indicating poor color for the 3.5% salt and best color for the 1.0% salt sauerkraut. Pederson and Robinson *(11)* have correlated color readings with quality and have shown that sauerkraut yielding (a) readings, in the + range are ordinarily poor in quality.

**TABLE 1**

**Effect of salt upon the development of acid and changes in bacterial flora in sauerkraut**

| Time days | Total acid % | Hydrogen ion concentration pH | Total plate count 100,000 per ml. | Estimated number of each type of bacteria, 100,000 per ml. | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Leuconostoc mesenteroides | Streptococcus faecalis | Pediococcus cerevisiae | Lactobacillus brevis | Lactobacillus plantarum |
| Series 3, 1951. 2.25% salt, 23° C. (73.4° F.), 232 cultures identified. | | | | | | | | |
| ½ | 0.15 | 4.48 | 1320 | 1320 | | | | |
| 1½ | 0.30 | 4.23 | 4400 | 4400 | | | | |
| 1½ | 0.74 | 3.93 | 9650 | 9150 | | | | 500 |
| 2½ | 0.77 | 4.00 | 4660 | 4660 | | | | |
| 2½ | 0.97 | 3.87 | 4490 | 4440 | | | | |
| 4 | 1.18 | 3.67 | 1250 | 687 | | 188 | 62 | 313 |
| 5 | 1.19 | 3.71 | 970 | | | 145 | 49 | 436 |
| 6 | 1.16 | 3.63 | 1410 | | | 20 | | 1270 |
| 8 | 1.42 | 3.68 | 4670 | | | 250 | 750 | 3170 |
| 10 | 1.57 | 3.59 | 2300 | | | | 1035 | 690 |
| 13 | 1.65 | 3.59 | 1200 | | | | 200 | 1000 |
| 17 | 1.61 | 3.58 | 546 | | | | | 546 |
| 21 | 1.78 | 3.51 | 251 | | | | 37 | 214 |
| Series 6, 1951. 3.5% salt, 23° C. (73.4° F.), 232 cultures identified. | | | | | | | | |
| ½ | 0.08 | 5.40 | 431 | 431 | | | | |
| 1½ | 0.10 | 4.82 | 1490 | 1490 | | | | |
| 5½ | 0.42 | 4.08 | 1275 | 1275 | | | | |
| 2½ | 0.58 | 4.19 | 3040 | 3040 | | | | |
| 2½ | 0.64 | 4.03 | 775 | 655 | | 80 | | 40 |
| 4 | 0.77 | 3.73 | 1270 | 572 | | 63 | | 254 |
| 5 | 0.97 | 3.75 | 1180 | 59 | | 295 | | 649 |
| 6 | 1.11 | 3.70 | 1450 | | | 458 | | 992 |
| 8 | 1.48 | 3.69 | 1070 | | | 240 | | 770 |
| 10 | 1.48 | 3.61 | 1200 | | | | | 467 |
| 13 | 1.51 | 3.60 | 400 | | | | 20 | 380 |
| 17 | 1.47 | 3.60 | 160 | | | | 36 | 124 |
| 21 | 1.51 | 3.58 | 57 | | | | | 57 |
| Series 7, 1951. 1.0% salt, 23° C. (73.4° F.), 242 cultures identified. | | | | | | | | |
| ½ | 0.38 | 4.21 | 4740 | 4266 | 474 | | | |
| 1½ | 0.67 | 4.17 | 7400 | 7030 | 370 | | | |
| 1½ | 0.98 | 3.93 | 9700 | 9700 | | | | |
| 2½ | 1.04 | 3.91 | 9400 | 9400 | | | | |
| 2½ | 1.10 | 3.86 | 11200 | 10500 | 700 | | | |
| 4 | 1.21 | 3.80 | 2840 | 2670 | | | | 170 |
| 5 | 1.25 | 3.81 | 625 | 313 | | | 62 | 250 |
| 6 | 1.28 | 3.79 | 810 | 120 | | | 80 | 610 |
| 8 | 1.50 | 3.72 | 1220 | 60 | | | 90 | 920 |
| 10 | 1.55 | 3.69 | 1095 | | | | 60 | 1035 |
| 13 | 1.95 | 3.67 | 950 | | | | | 475 |
| 17 | 1.91 | 3.59 | 545 | | | | 65 | 480 |
| 21 | 1.91 | 3.55 | 130 | | | | 20 | 110 |

The soft texture of all 1% salt sauerkrauts would make them unacceptable commercially. This texture relationship to salt content was better illustrated in the result from one of the earlier studies (Table 2). From these results, increasing tenderometer readings were noted as the salt content was increased to about 2.5%.

**The effect of temperature.** The differences in temperatures used in these studies have had a much greater effect upon the rate of fermentation (Table 3, Figure 2)

**TABLE 2**

**The effect of amount of salt on texture and acidity of sauerkraut**

| Salt added % | Salt content [c] % | | Tenderometer reading [d] % | | Total acid % | Volatile acid | |
|---|---|---|---|---|---|---|---|
| | A | B | A | B | | Percent | Percent of total acid |
| 0.50 | ..... | 0.50 | ..... | 29 | ..... | ..... | ..... |
| 0.75 | 0.85 | 0.87 | 96 | 45 | 1.74 | 0.26 | 15.0 |
| 1.00 | 1.14 | 1.08 | 125 | 66 | 1.76 | 0.32 | 18.3 |
| 1.25 | 1.31 | 1.44 | 123 | 95 | 1.72 | 0.27 | 15.8 |
| 1.50 | 1.57 | 1.62 | 134 | 117 | 1.79 | 0.28 | 15.6 |
| 1.75 | 1.75 | 1.97 | 141 | 130 | 1.79 | 0.28 | 15.8 |
| 2.00 | 2.05 | 2.07 | 153 | 130 | 1.72 | 0.26 | 14.8 |
| 2.50 | 2.46 | 2.58 | 165 | 151 | 1.67 | 0.24 | 14.3 |
| 2.75 | 2.89 | 2.84 | 146 | 149 | 1.54 | 0.21 | 13.9 |
| 3.00 | 3.07 | 3.15 | 152 | 169 | 1.46 | 0.18 | 12.5 |
| 3.50 | 3.42 | 3.47 | 169 | 150 | 1.47 | 0.20 | 13.6 |

[c] Color slightly dark at top in all samples containing more than 2.5% salt.

[d] Tenderometer readings taken upon kraut which had 22% by weight of juice removed by draining.

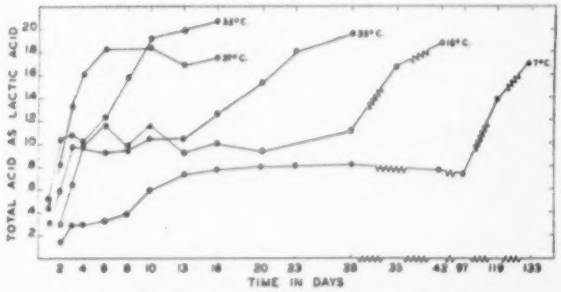


**Figure 2. The effect of temperature upon the development of acid and changes in pH in krauts packed in 1951.**

than did the differences in the salt contents studied. In 1951 the rates of fermentation were slightly greater than in 1949 and 1950. This was especially noticeable at the lowest temperature, 7.5° C. (45.5° F.). It may be noted (Table 3) that at 7.5° C. (45.5° F.) the leuconostoc remained viable for at least 90 days, although only 0.99% acid had been produced. Low acid producing strains of *Lactobacillus plantarum* developed slowly. After 97 days, this lot of kraut was placed in the 18° C. (64.4° F.) incubator in order to complete the fermentation. The acidity finally reached 1.79%. Correspondingly, low acidities of 1.15 and 1.14% were attained in 1949 and 1950 after 112 and 154 days respectively at

7° C. (45.5° F.) with growth of similar low acid producing strains. At 18° C. (64.4° F.) *Lactobacillus brevis* and *L. plantarum* developed more rapidly but many of the strains of the latter species isolated during the early stages of fermentation were of the low acid producing type. At 23° C. (73.4° F.) fermentation carried out by all three species, *L. mesenteroides, L. brevis* and *L. plantarum* followed a normal course in all 3 years. However, in 1951 (Table 1) a few strains of *Pediococcus cerevisiae* were isolated. The pediococci were more prevalent in the 1950 and 1951 series at both 32° C. (89.6° F.) and 37° C. (98.6° F.) and at the higher temperature apparently played a significant role in the fermentation. Streptococci were also present in fermentations conducted at the 2 higher temperatures and they must have had some effect on fermentation in 1949 and 1950 at the 37° C. (98.6° F.) temperature. It should be emphasized that regardless of temperature, the leuconostoc persisted in each fermentation until about the same acidity was attained. However, there is little doubt that other species were responsible for a greater part of the early fermentations at the higher temperatures than at the lower temperatures.

The maximum total acid each year was attained at 32° C. (89.6° F.) fermenting temperature. There was, however, no consistent relationship between pH and

**TABLE 3**

**Effect of temperature upon the development of acid and changes in bacterial flora in sauerkraut**

| Time days | Total acid % | Hydrogen ion concentration pH | Total count 100,000 per ml. | Estimated number of each type of bacteria, 100,000 per ml. | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Leuconostoc mesenteroides | Streptococcus faecalis | Pediococcus cerevisiae | Lactobacillus brevis | Lactobacillus plantarum |
| Series 1, 1951. 2.25% salt, 7.5° C. (45.5° F.), 299 cultures identified. | | | | | | | | |
| 1 | 0.04 | 5.82 | 40 | 40 | | | | |
| 2 | 0.10 | 5.54 | 158 | 158 | | | | |
| 3 | 0.09 | 5.49 | 510 | 510 | | | | |
| 4 | 0.22 | 5.11 | 760 | 760 | | | | |
| 5 | 0.29 | 4.81 | 1040 | 1040 | | | | |
| 6 | 0.33 | 4.72 | 1525 | 1525 | | | | |
| 8 | 0.48 | 4.58 | 3180 | 3180 | | | | |
| 10 | 0.51 | 4.47 | 2640 | 2640 | | | | |
| 13 | 0.58 | 4.40 | 2000 | 2000 | | | | |
| 20 | 0.70 | 4.21 | 2105 | 1935 | | | 170 | 67 |
| 27 | 0.68 | 4.24 | 1200 | 1133 | | | | |
| 34 | 0.83 | 4.22 | 925 | 880 | | | | |
| 41 | 0.82 | 4.22 | 790 | 316 | | | | 79 |
| 48 | 0.83 | 4.19 | 945 | 567 | | | | 142 |
| 55 | 0.85 | 4.13 | 400 | 120 | | | | 20 |
| 69 | 0.88 | 4.11 | 59 | 18 | | | | 3 |
| 90 | 0.99 | 4.07 | 57 | 9 | | | | 24 |
| 167 | 1.79 | 3.58 | 265 | | | | | 265 |
| Series 2, 1951. 2.25% salt, 18° C. (64.4° F.), 330 cultures identified. | | | | | | | | |
| 1 | 0.16 | 4.51 | 2150 | 2150 | | | | |
| 2 | 0.39 | 4.19 | 4440 | 4440 | | | | |
| 2½ | 0.70 | 4.10 | 5850 | 5550 | | | 300 | |
| 3 | 0.77 | 4.01 | 6900 | 6900 | | | | |
| 4 | 0.91 | 3.90 | 5550 | 4950 | | | 300 | 300 |
| 5 | 1.11 | 3.86 | 2730 | 2600 | | | | 130 |
| 6 | 1.12 | 3.80 | 1120 | 922 | | | 132 | 66 |
| 8 | 1.12 | 3.75 | 1325 | 789 | | | 178 | 358 |
| 10 | 1.23 | 3.70 | 2330 | | | 137 | | 2193 |
| 13 | 1.39 | 3.68 | 2000 | | | | 400 | 1500 |
| 17 | 1.59 | 3.59 | 1970 | | | | 100 | 1870 |
| 20 | 1.71 | 3.59 | 560 | | | | 180 | 380 |
| 27 | 1.56 | 3.55 | 390 | | | | 20 | 270 |
| 34 | 1.70 | 3.55 | 64 | | | | 25 | 36 |
| 41 | 1.77 | 3.58 | 25 | | | | 18 | 7 |
| 48 | 1.78 | 3.53 | 16 | | | | 12 | 4 |
| 55 | 1.77 | 3.55 | 4 | | | | 4 | |
| 69 | 1.80 | 3.52 | 4 | | | | 4 | |
| 90 | 1.79 | | | | | | | |
| Series 4, 1951. 2.25% salt, 32° C. (89.6° F.), 204 cultures identified. | | | | | | | | |
| ½ | 0.71 | 4.10 | 6400 | 6400 | | | | |
| 1½ | 0.82 | 3.97 | 6400 | 6400 | | | | |
| 1½ | 1.13 | 3.82 | 2410 | 2170 | | 120 | | 120 |
| 2½ | 1.01 | 3.78 | 4770 | | | 1325 | 265 | 1060 |
| 3½ | 1.36 | 3.78 | 6660 | | | 400 | 400 | 5800 |
| 4 | 1.56 | 3.60 | 6560 | | | | | 6560 |
| 5 | 1.71 | 3.58 | 2130 | | | | 220 | 1910 |
| 6 | 1.73 | 3.52 | 2335 | | | | | 2335 |
| 8 | 1.99 | 3.50 | 1530 | | | | | 1530 |
| 10 | 2.02 | 3.46 | 725 | | | | 99 | 593 |
| 13 | 1.96 | 3.48 | 230 | | | | 25 | 205 |
| Series 5, 1951. 2.25% salt, 37° C. (98.6° F.), 199 cultures identified. | | | | | | | | |
| ½ | 0.72 | 3.99 | 15600 | 14040 | 780 | 780 | | |
| 1½ | 0.82 | 3.98 | 8100 | 6500 | | 1200 | | 400 |
| 1½ | 1.09 | 3.83 | 6550 | | | 2750 | 1050 | 2750 |
| 2½ | 1.12 | 3.71 | 1665 | 166 | | 417 | | 1082 |
| 3½ | 1.31 | 3.56 | 3695 | 369 | | 739 | | 2400 |
| 4 | 1.52 | 3.55 | 1135 | | | | 67 | 1068 |
| 5 | 1.61 | 3.55 | 545 | | | | 83 | 462 |
| 6 | 1.54 | 3.50 | 405 | | | | 122 | 283 |
| 8 | 1.82 | 3.50 | 234 | | | | 37 | 197 |
| 10 | 1.76 | 3.50 | 48 | | | | | 46 |

acidity that could be correlated with temperature of fermentation as it could be in the salt concentration series. In different years the relationship was directly opposite in that at 32° C. (89.6° F.) and 37° C. (98.6° F.), one year the pH and acidity were comparatively lower and the other year higher than at 18° C. (64.4° F.) and 23° C. (73.4° F.). These relationships are apparently influenced by the relative effect of the heterofermentative and homofermentative species, an effectiveness which apparently is less consistent at different temperatures than at different salt concentrations.

Quality differences in the finished sauerkraut were not so pronounced in the temperature as in the salt series. Differences could be noted in color more markedly than in flavor and texture. In 1951 Hunter color difference meter (a) readings were —0.8, —0.6, —0.1, +1.7, and +1.6 for lots held at 7.5°, 18°, 23°, 32° and 37° C. (45.5°, 64.4°, 73.4°, 89.6° and 98.6° F.), respectively. This showed progressive darkening as temperature was increased. These readings for 32° and 37° C. (89.6° and 98.6° F.) lots would definitely indicate a C grading in color. It may be that these differences were entirely due to heat deterioration rather than to any differences in type of fermentation. Flavor and texture were also affected at 32° and 37° C. (89.6° F. and 98.6° F.) and at best such sauerkraut would not be given more than a fair rating in flavor. The texture tended toward toughness rather than the desirable crisp flavor of the sauerkraut fermented at the lower temperatures.

It can be stated that both salt concentration and temperature of fermentation are extremely important in the fermentation of sauerkraut. In this study the effects observed were more pronounced between the extremes in salt concentration than in the temperature. However, if the sauerkrauts fermented at high temperature had been allowed to remain for as long a period of time as might occur under commercial operating conditions, the temperature effect might have been much more pronounced. Above 23° C. (73.4° F.) the sauerkraut produced was unacceptable in color and texture, while at 7.5° C. (45.5° F.) the fermentation was greatly retarded.

In a previous study made at the fermentation temperature of 70° F. (21.1° C.) only *L. mesenteroides*, *L. brevis* and *L. plantarum* were found. The present study disclosed the presence and comparative importance of 2 other species, *P. cerevisiae* and *S. faecalis*. These were particularly noted in fermentations conducted at temperatures and at salt concentrations higher than normally used.

## SUMMARY

Salt content and temperature of fermenting sauerkraut influence not only the bacterial flora but the quality and chemical composition of the fermented sauerkraut.

In the lowest salt content sauerkraut of 1.0%, the heterofermentative species *Leuconostoc mesenteroides* and *Lactobacillus brevis* were favored. In the highest salt content sauerkraut of 3.5%, fermentation was retarded and the species *L. brevis* was almost entirely suppressed. Instead, strains of the species, *Pediococcus cerevisiae* were obtained more frequently than from lower salt content sauerkrauts, and in conjunction with the species *Lactobacillus plantarum* created more of a homofermentation than occurred in the sauerkrauts of lower salt content.

The suppression or favoring of different species was reflected in the pH-total acidity relationship. At the high salt concentration of 3.5%, lower acidity and lower pH were attained than in the low salt content sauerkrauts. This is a reflection of the greater comparative activity of the homofermentative species.

Sauerkrauts prepared with low salt concentrations were soft in texture but had good color. Those fermented with high salt concentrations were poor in color, flavor and texture.

The temperature had a marked effect upon rate of fermentation. At 7.5° C. (45.5° F.) fermentation did not progress sufficiently in several months to cure the sauerkraut. By contrast, at 32° C. (89.6° F.) and 37° C. (98.6° F.) a high acidity was attained in less than 2 weeks with the greater acidity attained at 32° C. (89.6° F.). This high acidity, however, does not mean that the product was well cured. Quality differences could be noted more markedly in color than in flavor.

In addition to the 3 species previously considered in sauerkraut fermentation, the species *Pediococcus cerevisiae* has been shown to be important in fermentations carried out at high temperatures or in high salt concentrations. The species *Streptococcus faecalis* has also been isolated in significant numbers.

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# Esters of Citric Acid in Stabilizing Edible Oils[a]

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**Uses of the esters of citric acid for stabilizing edible oils and fats are reviewed. The actions of these esters as metal deactivators and as inhibitors of flavor defects are demonstrated. A modification of the A. O. M. stability test is presented as a more critical evaluation method for oils and antioxidants.**

Vegetable oils are generally rich in natural antioxidants, chiefly the tocopherols, which are phenolic-type compounds. They are therefore more resistant to oxidation than the animal fats, which are practically devoid of natural antioxidants. This explains the practice of supplementing animal fats, such as lard, with phenolic-type antioxidants, e.g., propyl gallate *(13)* and butylated hydroxy-anisole *(6)*. Commercially processed oils and fats contain unavoidable trace metal contaminants, principally iron and copper. It is impractical and impossible to prevent the pick-up of these trace metals in the refining of oils and fats. In fact, the original seed or bean will contribute metals in amounts which in themselves are deleterious to the oil *(4)*. The practical solution to the problem of trace metals is the use of an edible organic acid, or its derivative, as a metal-deactivator.

One practice today is to add citric acid to the oils undergoing processing *(2)*. This method for stabilizing oils has several disadvantages. In the first place, a maximum of only about 0.005% citric acid can be dissolved in the oil. Also, heating of oils at the very high temperatures required for the rapid, though markedly limited, solution of free citric acid, viz., in the deodorization process, admittedly gives rise to a large number of different degradation products of known and unknown composition *(3, 8)*. Operational difficulties, such as plugging of valves with solid citric acid, may also be encountered. The concentration of free citric acid in such treated oils is therefore variable and unknown. Use of free citric acid for stabilizing an oil or fat permits no control over the quantity of agent present in the supplemented oil, unless it is added in exceedingly small, suboptimal quantities following deodorization.

In this laboratory, we have discovered that a particular class of citric acid esters may be readily added to oils without any of the disadvantages cited above. More particularly, the solution to this problem involved supplementation of oils, following deodorization, with one of the mono-esters of citric acid *(14)*.

**Esters of citric acid as metal deactivators.** During the course of these investigations, we were able to demonstrate that the esters of citric acid to be effective as metal deactivators must have 2 free carboxyl groups. Di- and tri-esters are completely inactive in this respect. The isopropyl citrate esters, predominantly monoisopropyl citrate, in a mono- and di-glyceride vehicle are particularly well adapted to the treatment of edible oils immediately following deodorization and preferably before exposure of the oils to air. The higher homologues, such as stearyl citrate, are soluble in oils and require no vehicle. Both the isopropyl *(1, 5, 10)* and stearyl citrate *(5)* esters have been approved by Federal agencies for stabilizing edible oils and fats. In so far as degree of effectiveness of their monoesters is concerned, the isopropyl and stearyl citrates are equivalent mol. for mol. They blanket the practical range of citrate esters from an economic standpoint.

In Figure 1, the individual and combined actions of the true antioxidant of the phenolic type and of the metal deactivator are

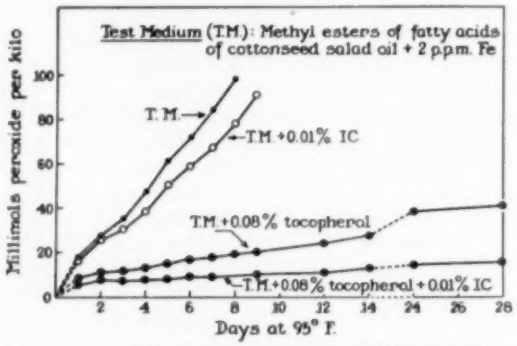
Test Medium (T.M.): Methyl esters of fatty acids of cottonseed salad oil + 2 p.p.m. Fe
Millimols peroxide per kilo
T.M.
T.M.+0.01% IC
T.M.+0.08% tocopherol
T.M.+0.08% tocopherol+0.01% IC
Days at 95° F.

**Figure 1. Individual and combined actions of phenolic-type antioxidants and of metal-deactivators in protecting fatty acid esters against atmospheric oxidation. IC indicates isopropyl citrate esters.**

demonstrated by means of a special test system. The test medium consists of specially prepared[b] methyl esters of cottonseed salad oil fatty acids to which has been added 2 p.p.m. of iron in the form of iron stearate. Such a medium is the equivalent of cottonseed salad oil free of antioxidants but containing metal pro-oxidants. One-hundred g. samples in pint-size mayonnaise jars were exposed to air at 95° F. At intervals, peroxide value determinations were made according to the method of Wheeler *(15)*. The metal-deactivating effect of mono isopropyl citrate is noted in the protection of the medium against oxidation. When tocopherol is added to the test medium, a marked stabilization against peroxide formation occurs; then, in the presence of the metal-deactivator plus tocopherol, a much greater re-

[a] Presented at the Thirteenth Annual Meeting of the Institute of Food Technologists, Boston, Massachusetts, June 23, 1953.

[b] The esters were prepared by alkaline-catalyzed methanolysis of cottonseed salad oil, which had been previously bleached with 5% Norit (American Norit Co., Inc., New York, N. Y.), followed by a vacuum-distillation. The distilled esters were then diluted with an equal volume of mixed hexanes (Skellysolve-B, Skelly Oil Co., Kansas City, Mo.), and the solution passed through a column made up of a mixture of equal weights of Norit and Johns-Manville Hyflo Supercel. The solvent was removed by means of a vacuum-stripping and the esters were once again vacuum-distilled. This distillate was then subjected to acetylation employing a reaction mixture of 500 g. of esters, 100 ml. of acetic anhydride, and 3 drops of concentrated sulfuric acid as catalyst, in order to inactivate any residual tocopherol. The reaction product was washed thoroughly with hot water and after drying was subjected to two successive vacuum-distillations. The final distillate was stored at 25° F. overnight and used the next morning in the test discussed above. This obviously overcautious procedure was used in an attempt to obtain a tocopherol-free substrate. The Rawlings modification *(11, 12)* of the Emmerie-Engel method showed no tocopherols in the esters prepared in this manner.

sistance to oxidation is attained, as revealed by an examination of the slopes of the respective curves. The monoesters of citric acid exhibited no activity in protecting the distilled methyl esters free of trace metals and polyphenolic antioxidants; the same effect has been noted with free citric acid in comparable test systems *(7)*.

In Figure *2* is illustrated an application of the pure monoesters of citric acid in the stabilization of commercial salad oils against oxidation. The test and analyses were run in the same manner as described above in connection with Figure 1. Both these oils contained by analysis *(11, 12)* natural tocopherols in about 0.08% concentration. In the upper half of this figure the lack of function on the part of the distearyl ester is apparent, while the mono-ester is markedly effective in protecting corn salad oil from peroxide formation. The striking differences in the stability of soybean salad oil with and without a monoisopropyl citrate supplement are pictured in the lower portion of Figure 2. An extensive program based on studies such as these demonstrated that commercially refined and deodorized oils containing unavoidable trace metal contaminants can be readily stabilized by means of the mono-esters of citric acid.

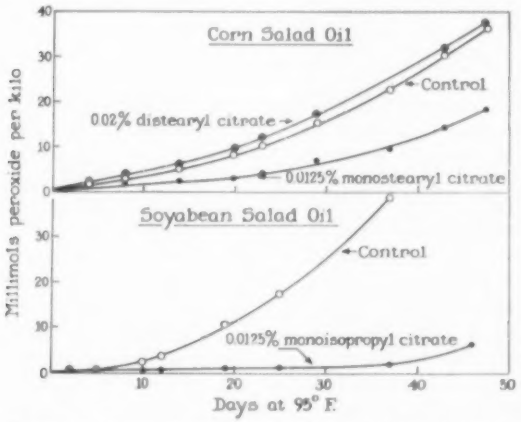


**Figure 2. Protection of commercial salad oils against atmospheric oxidation following supplementation with pure citric acid esters. Oils contain approximately 0.08% native tocopherols.**

**Flavor tests using an expert panel.** Evaluation of the effectiveness of the ester preparations for uses on a practical scale has not been based solely on peroxide value determinations. Repeatedly, various oil samples under code were subjected in our laboratory to flavor scorings by an expert panel in order to evaluate the stabilizing influence of the esters in protecting the flavor life of edible oils. For these tests covering oils stabilized according to current commercial practices, the readily available mixed citric acid esters were employed. The isopropyl citrate esters were predominantly monoisopropyl citrate, while the stearyl citrate esters were predominantly the diester, still containing an effective concentration of monostearyl citrate.

As an illustration of the effectiveness of the commercially available citrate ester preparations, the results of one objective flavor scoring study are presented in Figure 3. All samples were refined deodorized oils derived from the same starting refined soybean oil: The first sample was a soybean salad oil; the second, the same soybean oil hydrogenated for margarine manufacture; and the third, the same soybean oil hydrogenated for shortening manufacture. Half-filled quart-size mayonnaise jars containing the samples were stored under air at 95° F. The oils were scored at 2-week intervals by a panel consisting of 8 people well experienced in evaluating oil flavors. At scoring times, the samples were removed from the 95° F. room, melted where necessary and 5-g. portions for each panel member were poured into small brown bottles. This procedure permitted the careful warming of each flavor sample as the panel member was available for scoring without repeated meltings of the large storage sample. The average numerical scores reported by the panel

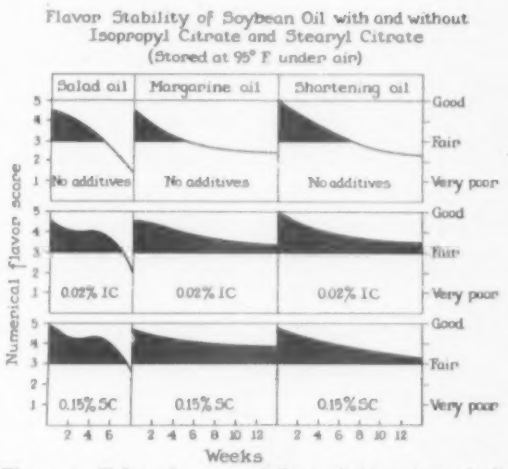


**Figure 3. Value of commercially available esters of citric acid in stabilizing the flavor of limpid and hydrogenated soybean oil.**

were plotted and the best-fitting curves drawn through the plot points. The point at which a curve crosses the horizontal line, representing a score of *3*, i.e. an oil *fair* in flavor, represents the relative shelf life. In addition, the areas under the curves and above the "3" score line have been shaded to reflect not only the relative shelf life but also the degree of acceptability during the *better than fair* period. It is seen in Figure *3* that not only are the flavor lives of the oils extended by the use of the citrate esters, but also the "overall flavor" performances of the oils (as represented by the shaded areas) are markedly improved.

As shown in Table I, the relative shelf life of the limpid soybean oil is extended by about 50% as a result of supplementation with the esters of citric acid and that of the hydrogenated oils more than doubled or tripled. The overall picture of flavor acceptance, as represented by the shaded areas in Figure *3*, is shown numerically here to be improved by from 50 to 100% in the case of the limpid oil and by from at least 90 to over 300% in the case of the hydrogenated oils. In other words, the esters have also contributed to the maintenance of a higher degree of flavor acceptance during the period when the oils were satisfactory in flavor. Apparent shelf life based solely on peroxide value determinations in these same test systems seemed to indicate a 5-fold improvement. This comparison emphasizes that a more

**TABLE 1**

**Performance of isopropyl and stearyl citrates in stabilizing the flavor of soybean oil stored under air at 95° F.**

| Oil | Additives | Relative shelf life[c] (weeks) | Overall flavor[d] performance |
|---|---|---|---|
| Salad oil | None | 5 | 215 |
| | 0.02% IC | 7 | 325 |
| | 0.15% SC | 7½ | 425 |
| Margarine oil | None | 5 | 165 |
| | 0.02% IC | 14+ | 550+ |
| | 0.15% SC | 14+ | 700+ |
| Shortening oil | None | 7 | 315 |
| | 0.02% IC | 14+ | 625+ |
| | 0.15% SC | 14+ | 600+ |

[c] Number of weeks scored above *fair*.

[d] Relative shelf life × degree of acceptability; i.e., the area in sq. mm. above *fair* level under curve as originally plotted.

complete study of the flavor life of an edible oil is obtained by peroxide values supported by actual flavor scorings.

**Tests using the A. O. M. method.** The A. O. M. test is frequently used to evaluate antioxidants. This procedure has a very important use as a control method for routine production of a single class of oil products. However, A. O. M. stability tests are usually conducted in an all-glass apparatus on freshly processed oils. The citation of such data neglects the possibility

of changes in the values due to subsequent metal pickup. Oils are transported from refiner to bulk users in sheet iron tank cars. Users cream the fat with other ingredients in sheet iron mixers, or fry the products in sheet iron vats. Then, why conduct A. O. M. tests only in glass? A. O. M. tests on oils relatively free of metals can fail to predict which oil is better protected against subsequent metal pickup. In this laboratory, the A. O. M. Stability Test has been modified for investigative purposes by replacing the glass tubes with iron tubes of the same design. The advantages and limitations of the modified procedure as a research tool are fully discussed elsewhere *(9)*. The usual peroxide value determinations are supplemented with flavor scorings of the oils as they undergo oxidation. For comparative purposes, tests using the all-glass apparatus are also conducted.

In Figure 4 are presented the results of a study of commercially available shortening products. With the exception of

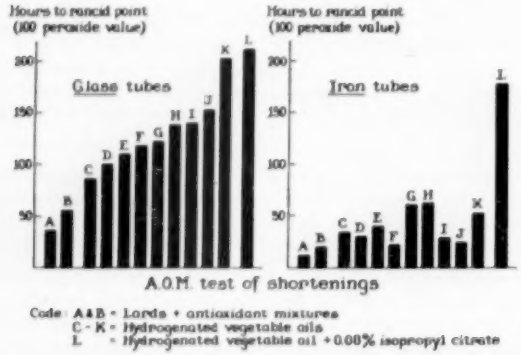
Hours to rancid point
(100 peroxide value)
Glass tubes
Iron tubes
A O.M. test of shortenings
Code: A & B = Lards + antioxidant mixtures
C - K = Hydrogenated vegetable oils
L = Hydrogenated vegetable oil + 0.08% isopropyl citrate

**Figure 4. The marked decreases in A. O. M. stability values when shortenings are aerated in iron tubes.**

Samples A and B which were lard products supplemented with antioxidants, all the other shortenings were hydrogenated vegetable oils. The striking decreases in the A. O. M. stability values when the tests are run in iron tubes are quite apparent in all samples except one. Only in the case of shortening "L," containing the relatively high level of isopropyl citrate, 0.08%, a concentration not obtainable with free citric acid, is the resistance to oxidation maintained to almost the same degree as that in glass tubes.

A comparable study, as exhibited in Figure 5, deals with the evaluation of antioxidants by means of the customary and the modified A. O. M. test. In this particular series, the same hydrogenated vegetable oil was used throughout, but supplemented with different antioxidants, alone and in combinations

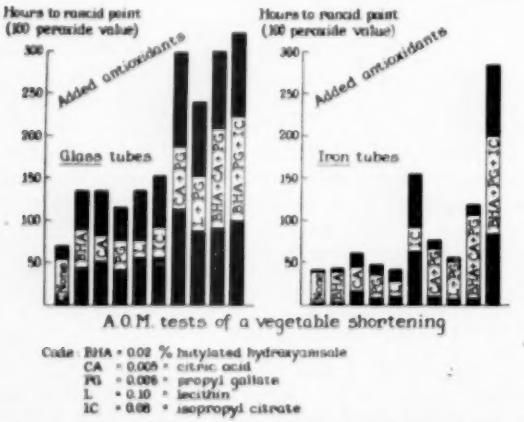
Hours to rancid point
(100 peroxide value)
Added antioxidants
Glass tubes
Iron tubes
A O.M. tests of a vegetable shortening
Code: BHA = 0.02 % butylated hydroxyanisole
CA = 0.005 = citric acid
PG = 0.006 = propyl gallate
L = 0.10 = lecithin
IC = 0.08 = isopropyl citrate

**Figure 5. The effectiveness of isopropyl citrate, predominantly the mono-ester, in protecting shortening against oxidative deterioration accelerated by iron catalysis.**

in the customary concentrations used commercially as indicated. From the results obtained in glass tubes, various antioxidant combinations are apparently superior to the isopropyl citrate used as sole protecting agent. However, when the tests are conducted in iron tubes, this is not the case. Under these accelerated conditions of test, providing for oxidative deterioration of the oils promoted by metal pickup and contact metal catalysis *(9)*, conditions encountered during commercial operations, the relatively high concentration of isopropyl citrate confers a degree of stability strikingly superior to that attained with the other antioxidants, whether alone or in combinations. The best combination of antioxidants appears to be that including butylated hydroxy-anisole, propyl gallate, and isopropyl citrate. Flavor scorings conducted on all these test systems supported the A. O. M. values reported.

The results presented in Figures 4 and 5 are representative of a number of such studies. The precision of the tests conducted on oils and on antioxidants in iron tubes has been found to be almost as good as that obtained with the unmodified procedure *(9)*. The values are reproducible in the authors' laboratory to within $\pm$ 2 hours. It is apparent from Figures 4 and 5 that citric acid itself cannot be readily incorporated in oils in the concentrations necessary to produce the effects obtainable with monoisopropyl citrate.

## SUMMARY

The necessity of adding a metal-deactivating agent for stabilizing oils and fats against oxidation and flavor reversion is emphasized. Citric acid is an effective material, but in using this compound, the processor has no control over what remains qualitatively and quantitatively in the finished oil, not to mention the possibility of operational problems when the addition is made during the deodorization stage. These criticisms do not apply when the esters of citric acid are employed after deodorization. Ease of use and ready solubility very definitely favor the esters of citric acid. Far higher concentrations of metal-deactivator compounds in oils are readily attained with the esters of citric acid for counteracting the pro-oxidant effects of metals. This is illustrated by results obtained from a modified A. O. M. test procedure involving aeration of oils in iron tubes rather than in glass.

The plea is made that objective flavor scorings be carried out more often on oil and fat products held under realistic conditions of storage before generalizations on flavor life are drawn. Peroxide value determinations are of greater value when supplemented by such flavor scorings.

### Acknowledgment

The authors are indebted to Miss Betty A. White of The Best Foods' Laboratory for conducting the flavor panel studies mentioned in this report.

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# Studies on the Dehydration of Sweet Corn[a,b]

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(Manuscript received July 3, 1953)

**Effects of six preparation and three storage variables on the acceptability of dehydrated sweet corn were determined by means of a fractionally replicated experiment. Sulfur dioxide content was shown to be the most important single variable. Storage temperature, especially at 100° F. and 115° F., exerted a strong effect, as did moisture content initially and, by interacting with other variables, after 6-months' storage. The best combination of conditions for sweet corn dehydration is described.**

Sweet corn ranks high in acceptability with the American people. In view of this fact it appears that dehydrated sweet corn might offer an excellent field ration item for the Armed Forces.

Published literature gives little information on the dehydration of sweet corn. Several workers *(2, 7, 9)* have carried out research studies on various phases of sweet corn dehydration, and their general conclusions indicate definite possibilities for the product. However, some phases of the preparation and dehydration process have not been investigated. Furthermore, no one has integrated preparation, dehydration, packing, and storage factors into one experiment in such a manner that main effects and two-factor interactions might be compared.

The objective of the research described in this paper was to develop a procedure for preparation, dehydration, and packaging of dehydrated sweet corn that would yield an acceptable product after 6 months' storage at 100° F.

## EXPERIMENTAL PROCEDURE

This study included the evaluation of the effects of 6 preparation and 3 storage variables on the acceptability of dehydrated sweet corn. These variables involved the factors of maturity, cob *vs.* cut corn blanching, short- and long-time blanching, water- and steam-blanching, sulfite treatment, dehydration procedure, moisture level, nitrogen or air packing, and storage temperature.

Golden Cross hybrid was selected as the variety of sweet corn for this experiment. The raw material for each dehydration run was harvested just prior to preparation and processing. A 1924 model Peerless corn husker and a 1935 model Universal corn cutter were used in husking and cutting the corn from the cob. The sweet corn was harvested over a period of about 3 weeks from 6 plantings totaling 8 acres.

Maturity was evaluated from moisture determinations by the vacuum oven method *(3)*. Procedures were: Raw corn was ground in a meat grinder, and duplicate samples of approximately 10 g. each weighed on a torsion balance to ±0.01 g. These were predried in an air oven at 80° C. for 5 hours and then placed in the vacuum oven for 5 hours at 95° C. under a pump pressure below 100 mm. Hg. A stream of air dried in a sulfuric acid tower was passed through the oven during the drying period. The dishes were then cooled, weighed, and replaced in the vacuum oven for one hour so that a check weighing could be made.

To determine moisture content of dehydrated sweet corn, the sample was ground in a Waring blender for 2 minutes, and duplicate 10 g. portions were weighed on a torsion balance to ±0.01 g. These were dried at 70° F. for 16 hours in the vacuum oven as described above.

Short blanching times for cut sweet corn were adequate for inactivation of peroxidase enzyme when tested in accordance with the Western Regional Research Laboratory peroxidase test *(11)*. Longer blanching times were arbitrarily selected. Blanching times were:

| Cut corn | Cob corn |
|---|---|
| a. Steam—long blanch ... 5' 35" | a. Steam—long blanch ... 16' |
| b. Steam—short blanch ... 2' | b. Steam—short blanch ... 8' |
| c. Water—long blanch ... 5' 35" | c. Water—long blanch ... 16' |
| d. Water—short blanch ... 2' | d. Water—short blanch ... 8' |

Steam- and water-blanching were accomplished at atmospheric pressure at about 209° F. Two gallons of softened water were used to blanch 40 pounds of cut corn. The blanched cut corn was cooled by fluming a distance of 18 feet in tap water. Cob corn was blanched with enough softened water just to cover the product and was cooled with water sprays.

Three levels of sulfite treatment plus a control were used. These levels were selected following an examination of the

[a] This paper reports research undertaken in cooperation with the Qm. Food and Container Institute for the Armed Forces. Opinions or conclusions contained herein do not necessarily represent those of the Department of Defense.

[b] Presented at the Thirteenth Annual Meeting of the IFT, Boston, Massachusetts, June 24, 1953.

literature *(3, 7, 8)* dealing with sulfiting of dehydrated vegetables and after making some preliminary runs. The low sulfite (0.5% sulfur dioxide solution) was made up with 67 g. $Na_2SO_3$ plus 56 g. $NaHSO_3$ in 30 pounds of softened water. A pH of 6.7 was used by adjustment of the solution, if necessary, with dilute HCl or NaOH. Sulfite solutions containing 1.0% and 2.0% sulfur dioxide concentrations were made similarly. These sulfite solutions were used to treat 80 pounds of cut corn. Before being placed in the dehydrator, the prepared corn was submerged in the sulfite solution for one minute and then drained for a 5-minute period.

The Potter and Hendel *(6)* modification of the sulfite determination by Prater *et al.* was used. This modification, developed for work with dehydrated white potato, involves a direct iodine titration with formaldehyde used as binding agent in the blank determinations. In adapting this method to sweet corn, 3 changes were made in the procedure. The dehydrated sample was ground in a Bodine mill and passed through a 20-mesh screen. The volume of 5N HCl was reduced from 7.0 ml. to 6.0 ml. so that the pH was 2.4, and a magnetic mixer was substituted for the mechanical type suggested.

Within experimental limitations 4 dehydration conditions were used which reasonably simulate the drying conditions in several types of commercial dehydrators now in use. The first dehydration method was characterized by the passage of air through product and tray. This drier was originally designed for drying sweet corn seed; maximum operating temperature was about 135° F. For reduction of moisture content of sweet corn to about 20%, the drying time of the product in this drier was roughly 5 hours. Four trays were superimposed, one above another, and the air was drawn down through product and trays. The trays were approximately 12 inches apart, and the total depth of corn in the 4 trays was about 5 inches. General operating conditions included:

*a.* Initial air temperature, about 130° F.
*b.* Dry bulb temperature at air discharge at beginning of run, about 100° F.
*c.* Wet bulb temperature at air discharge at beginning of run, about 80° F.
*d.* Dry bulb temperature at air discharge at end of run, about 128° F.
*e.* Wet bulb temperature at air discharge at end of run, about 84° F.
*f.* Time elapsed during runs, approximately 5 hours.
*g.* Drying weight reduction, approximately 3.2 to 1.
*h.* Air flow through tray, 200 lineal feet per minute.
*i.* Tray load, 2.94 pounds per square foot per tray.

Drying conditions *b*, *c*, and *d* were carried out in a cross tray drier in which air passed across the product and trays. This drier contained 10 trays 2 feet by 2 feet, which were suspended in a rack resting on a large-sized solution balance. The removal of water could thus be followed during the entire dehydration run. A straight-line calibration curve of tray load and balance reading was obtained. This arrangement allowed a semicontinuous measurement of the drying progress without disturbing the operation. Drying conditions were changed at predetermined corn weights in an effort to simulate operation in various types of commercial cross-flow driers. The U.S.D.A. Dehydration Manual *(8)*, the Bureau of Plant Industry Studies *(2)*, and the Research Reports on Quartermaster Contract Projects *(7)* were considered when the wet and dry bulb temperatures were selected for the various drying runs.

On all dehydration runs with drying conditions *b*, *c*, or *d*, a Steinlite moisture determination *(3)* was made on prepared corn just before it was placed in the drier. These data were used to calculate the T values (ratio of water to dry matter) as follows:

$$T_o = \frac{\%\ \text{moisture}}{(100 - \%\ \text{moisture})}.$$

The net weight desired for each step in the drying run was calculated as

$$\text{initial weight} \times \frac{(100 - \%\ \text{moisture}) \times (T_f + 1)}{100},$$

where $T_f$ is the condition desired. The drying time taken to reach these calculated weights, as well as intermediate weights, was recorded.

Drying condition *b* was designed to simulate a center-exhaust drier in which air passes across the product and tray. The dehydration run was carried out in 4 steps as follows:

*Step No. 1.* 220° F. dry bulb
120° F. wet bulb

This condition maintained until moisture content was reduced to 1.5 lb. water per pound of bone-dry corn. From $T_o$ to $T = 1.5$.

*Step No. 2.* 190° F. dry bulb
100° F. wet bulb

This condition maintained until moisture content was reduced to 1.2 lb. water per pound of bone-dry corn.

From $T = 1.5$ to $T = 1.2$

*Step No. 3.* 150° F. dry bulb
100° F. wet bulb

This condition maintained until moisture content was reduced to 0.6 lb. water per pound of bone-dry corn.

From $T = 1.2$ to $T = 0.6$

*Step No. 4.* 160° F. dry bulb
100° F. wet bulb

This condition maintained until moisture content was reduced to 0.2 lb. water per pound of bone-dry corn.

From $T = 0.6$ to $T = 0.2$

Time elapsed during runs was about 2.5 to 3.5 hours; air flow across trays adjusted to 800 lineal feet per minute; tray load, 2 lb. per square foot.

Drying condition *c* was designed to simulate a cross flow parallel type drier in which relatively low initial air temperatures were employed. The dehydration process was carried out in 3 steps as follows:

*Step No. 1.* 190° F. dry bulb
100° F. wet bulb

This condition maintained until moisture content was reduced to 1.8 lb. water per pound of bone-dry corn.

From $T_o$ to $T = 1.8$

*Step No. 2.* 175° F. dry bulb
100° F. wet bulb

This condition maintained until moisture content was reduced to 0.8 lb. water per pound of bone-dry corn.

From $T = 1.8$ to $T = 0.8$

*Step No. 3.* 160° F. dry bulb
100° F. wet bulb

This condition maintained until moisture content was reduced to 0.2 lb. water per pound of bone-dry corn.

From $T = 0.8$ to $T = 0.2$

Time elapsed during run was about 2.75 to 3.5 hours; air flow across trays adjusted to 800 lineal feet per minute; tray load, 2 lb. per square foot.

Drying condition *d* was designed to simulate a cross flow parallel type drier in which high initial air temperatures were employed. The dehydration process was carried out in 3 steps as follows:

*Step No. 1.* 220° F. dry bulb
120° F. wet bulb

This condition maintained until moisture content was reduced to 1.5 lb. water per pound of bone-dry corn.

From $T_o$ to $T = 1.5$

*Step No. 2.* 190° F. dry bulb
100° F. wet bulb

This condition maintained until moisture content was reduced to 0.8 lb. water per pound of bone-dry corn.

From $T = 1.5$ to $T = 0.8$

*Step No. 3.* 160° F. dry bulb
100° F. wet bulb

This condition maintained until moisture content was reduced to 0.2 lb. water per pound of bone-dry corn.

From T = 0.8 to T = 0.2

Time elapsed during run was about 2.5 to 3.5 hours; air flow across trays adjusted to 800 lineal feet per minute; tray load, 2 lb. per square foot.

After the initial dehydration runs were completed, the product was placed in 30-pound, friction-top, sanitary enamel-lined tin cans and held about 3 days in 32° F. storage until bin drying could be accomplished. The corn was finish-dried in the through-air-flow dehydrator.

The samples that were to be stored at the high moisture levels were finish-dried twice with several days' holding period between drying runs. The first run was characterized by a 5-hour drying time, while in the second run the time elapsed was 4 hours. The dry bulb temperature was about 130° F., and the wet bulb temperature about 85° F. The product from the second run was divided into ⅓ and ⅔ portions, and the larger amount was held for several days at 32° F. to allow equilibration and then packed as a high-moisture product. The lesser amount was again dried in a single 8-hour run under conditions as described above. This drying was carried out at night to take advantage of the lower absolute moisture content of cool night air. The latter product was held for several days and then packed as low moisture corn. The average of the high-moisture samples was 6.0%; the low-moisture corn contained an average of 4.6% moisture.

No. 1 picnic 211 x 400 plain tin cans were used for packaging the dried products. Four and one-half to 5 ounces of product were placed in each can, depending upon the amount of produc. available and the bulk density of the corn. Nitrogen packing was accomplished with a Pacific No. 1 American Can closing machine. A vacuum of 27 inches was drawn in the chamber in which the can was placed and held for 60 seconds, after which the vacuum was released with nitrogen gas and the cover sealed. The highest quality commercial nitrogen available was used.

Following the packaging of samples, individual cans were selected by the use of random numbers for designated storage temperature and order of removal from storage. Storage temperatures of 115° F., 100° F., 85° F., and 70° F. were established. Examinations were carried out immediately and after storage periods of 1.5 months, 3 months, and 6 months.

Organoleptic testing included the evaluation of 4 factors: (a) natural flavor, (b) off-flavor, (c) color and appearance, and (d) texture. These factors were scored on the basis of 1 to 10, with 5 being considered acceptable, 1 very poor, and 10 excellent. Flavor concerns the presence or absence of normal sweet corn taste and aroma, while off-flavor covers the presence of sulfite, stale, scorched, or other unnatural flavors or odors. The factors were averaged and weighted as follows:

| | |
|---|---|
| Flavor, Off-flavor } averaged together | × .5 |
| Color and appearance | × .3 |
| Texture | × .2 |

A final score of 5 indicated that the product was acceptable. Three to 5 testers were used for each organoleptic examination. This taste panel was comprised of graduate students and staff members.

The dehydrated sweet corn was prepared for organoleptic testing as follows: Fifty g. of dried corn was placed in 500 ml. Erlenmeyer flasks and 200 ml. of zeolite softened water plus 7 ml. of a saturated sodium chloride solution was added. After a 1.5-hour soaking period at room temperature, the water was drained from the corn for 3 minutes, the corn was weighed, and the volume of soak water was measured. The water and corn were then returned to the flask fitted with a glass joint type of water condenser, and the assembly was placed on an electric hot plate. The contents were allowed to simmer for 30 minutes, after which the weight of corn and the volume of remaining water were determined as before. Both the corn and the liquid were transferred to white porcelain product pans for the organoleptic evaluation.

## EXPERIMENTAL DESIGN

This investigation involved the evaluation of the effects, singly and in combination, of 5 factors at 2 levels and 3 factors at 4 levels. A single replicate of this experiment would include 128 dehydration runs and 2,048 individual storage conditions. Such an experiment was far too extensive for the resources available. The solution to this problem was found in a fractionally replicated design using one-fourth of the 2,048 individual combinations, or 512 treatments *(5)*. Included in the one-fourth replicate factorial design were 64 dehydration runs and 512 individual storage conditions.

Maturity of the raw material presented a variable that could not be controlled. Therefore, the factor of maturity differences was considered on the basis of a statistical analysis of covariance. Vacuum oven moisture, initial organoleptic value, 6-month organoleptic value, initial total rehydration water and 6-month total rehydration water were used in the statistical analysis to determine the existence of single effects and two-factor interactions. The statistical procedure used to evaluate the effect of the factors of preparation, packaging, and storage on the initial and 6-month organoleptic data was analysis of variance. This experiment was so extensive in scope that results were not considered significant below the 99% confidence level. Table 1 portrays the resulting analysis with the exception that sums of squares for nonsignificant main effects and 2-factor interactions are not individually presented.

**TABLE 1**
**Effects of eight variables on the preparation and storage of dehydrated sweet corn**

| Source of variation | Analysis of variance | | | | |
|---|---|---|---|---|---|
| | Degrees of freedom | Sum of squares | Mean square | Variance ratio | Probability |
| **Six-Month Organoleptic** | | | | | |
| Sulfite level | | | | | |
| Linear | 1 | 206.42 | 206.42 | 82.24 | 0.001— |
| Quadratic | 1 | 62.65 | 62.65 | 24.96 | 0.001— |
| Others + interactions | 37 | 32.47 | 0.88 | (3.40) | 0.99 + |
| Error I | 24 | 60.21 | 2.51 | 3.03 | 0.001— |
| Dryness + interactions | 10 | 7.55 | 0.76 | (1.10) | 0.8 — |
| Error II | 54 | 44.79 | 0.829 | (1.23) | 0.8 — |
| Storage temperature (T) | | | | | |
| Linear | 1 | 544.74 | 544.74 | 533.01 | 0.001— |
| Quadratic | 1 | 24.46 | 24.46 | 23.93 | 0.001— |
| T × on or off cob | | | | | |
| Linear | 1 | 64.67 | 64.67 | 63.28 | 0.001— |
| T × sulfite level | | | | | |
| Lin. × Lin. | 1 | 0.08 | 0.08 | (12.8) | 0.8 — |
| Lin. × Quad. | 1 | 15.50 | 15.50 | 15.17 | 0.001— |
| Lin. × Cub. | 1 | 11.62 | 11.62 | 11.37 | 0.001— |
| T × dehyd. cond. | | | | | |
| Linear | 3 | 6.54 | 2.18 | 2.13 | 0.1 — |
| Quadratic | 3 | 1.59 | 0.53 | (1.93) | 0.8 — |
| Cubic | 3 | 13.79 | 4.60 | 4.51 | 0.01 — |
| T × dryness | | | | | |
| Linear | 1 | 28.79 | 28.79 | 28.17 | 0.001— |
| Quadratic | 1 | 11.13 | 11.13 | 10.89 | 0.001+ |
| Others + interactions | 30 | 38.31 | 1.28 | 1.25 | 0.2 — |
| Error III | 337 | 344.36 | 1.022 | | |
| **Initial Organoleptic** | | | | | |
| On or off cob | 1 | 27.06 | 27.06 | 22.6 | 0.001— |
| Sulfite level | 3 | 401.74 | 133.91 | 111.6 | 0.001— |
| Other + interactions | 35 | 45.94 | 1.313 | 1.09 | 0.8 — |
| Error I | 24 | 28.80 | 1.200 | 2.06 | 0.01 + |
| Dryness | 1 | 18.49 | 18.49 | 31.7 | 0.001— |
| Interactions | 9 | 12.64 | 1.404 | 2.41 | 0.05 — |
| Error II | 54 | 31.47 | 0.583 | 1.04 | 0.8 — |
| "Dummy comparisons" + interactions | 384 | 214.15 | 0.558 | | |

Probability 0.01— denotes significance at the 1% level.

## RESULTS AND DISCUSSION

Sulfur dioxide concentrations in the dehydrated product were found to exert highly significant effects on both the initial and 6-month organoleptic scores (Table 2). Sulfite level was by far the most important single factor, and the effect of sulfur dioxide concentra-

tion was evident directly and indirectly by interacting with several other variables. Sulfur dioxide treatment of the blanched corn was definitely necessary to minimize undesirable changes in the product during the dehydration process and to increase storage stability, especially when storage temperatures exceeded 70° F.

The similar dehydration runs of cob and cut corn were subjected to like sulfite treatments. However, for some unknown reason, the corn cut from the cob and then blanched absorbed more sulfur dioxide than the similarly treated cob blanched samples. Both cob and cut corn samples were subjected to the sulfite dip immediately before the product was placed on the dehydration trays, and sulfiting procedures were alike. The cut corn blanched samples subjected to the high sulfite treatments contained almost twice the concentration of sulfur dioxide found in like sulfited cob blanched samples (Table 3). During the initial organoleptic examination the concentration of sulfur dioxide in the cob blanched samples was generally considered to be acceptable, while the similar cut corn samples were often found to be objectionable in sulfur dioxide flavor. Thus the average organoleptic values for the high sulfur dioxide levels (Table 2) represent both cut and cob blanched corn samples in which the acceptability as regards sulfur dioxide flavor ranged from poor to very good.

Storage temperature exerted a highly significant effect, especially at 100° F. and 115° F. and after 3- and 6-month holding times (Table 4). It is evident that the 115° F. storage temperature results in a generally unacceptable product after a period of 3 months. Temperatures of 70° F. and 85° F. for storage periods of 6 months resulted in a lowering of the average scores. However, these samples were still acceptable after the 6-month storage period. This reduction in score may be largely attributed to the samples in which no sulfite was used. Apparently temperatures of 70° F. and 85° F. affect the sulfite little, if any, while at 100° F. and

**TABLE 3**

**Average initial sulfur dioxide contents of dehydrated sweet corn prepared for storage at two moisture levels**

**(Sulfur dioxide content in parts per million)**

| High $SO_2$ treatment | | | | Medium $SO_2$ treatment | | | | Low $SO_2$ treatment | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| High moisture | | Low moisture | | High moisture | | Low moisture | | High moisture | | Low moisture | |
| Cob | Cut | Cob | Cut | Cob | Cut | Cob | Cut | Cob | Cut | Cob | Cut |
| 1,891 | 3,091 | 1,792 | 2,867 | 1,062 | 1,737 | 926 | 1,687 | 614 | 755 | 578 | 705 |

especially 115° F. the breakdown of sulfite is substantially accelerated over a 6-month holding period (Table 4). It is evident that storage temperature offers a strong single and interacting factor that is second only to sulfur dioxide concentration in effect.

The interaction of sulfite level and storage temperature produced a significant effect on 6-month organoleptic scores. This combination covers two very important interacting factors. Samples with low-sulfite treatment were quite acceptable initially, but the sulfur dioxide concentration was not high enough to give protection for 6 months when stored at 100° F. or 115° F. Medium sulfite treatments were generally acceptable initially and fairly acceptable after 6 months' storage at 100° F. High sulfite treatments were often objectionable because of sulfur dioxide flavor during the initial examination but showed good storage stability, especially following 3- and 6-month periods at 100° F. (Tables 2 and 5).

It seems evident that a temperature of 115° F. causes excessive deterioration of dehydrated corn when stored as long as 6 months. High sulfite counteracted, to a limited degree, the effect of the 115° F. storage, but the protection was not sufficient to yield an acceptable product after the long storage period. The medium and high sulfite levels in the samples generally gave satisfactory protection when storage temperatures were lower than 115° F. Therefore, the optimum sulfite treatment depends upon the temperature and time of storage intended for the product.

**TABLE 2**

**Effect of sulfite treatment and storage times on the acceptability of the dehydrated sweet corn**

| Treatment | Total samples | Initial vacuum oven moisture (raw product) | Moisture content of dried corn | Original $SO_2$ | 6 mo. $SO_2$ | Initial exam. | | 1½ mo. exam. | | 3 mo. exam. | | 6 mo. exam. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total hydration after cook. | Organoleptic | Total hydration after cook. | Organoleptic | Total hydration after cook. | Organoleptic | Total hydration after cook. | Organoleptic |
| Average values | | | | | | | | | | | | | |
| | | % | % | *p.p.m.* | *p.p.m.* | *g.* | | *g.* | | *g.* | | *g.* | |
| 0 — $SO_2$ | 128 | 72.7 | 5.23 | 0 | 0 | 123 | 4.9 | 121 | 5.0 | 101 | 3.5 | 110 | 3.3 |
| Low $SO_2$ | 128 | 72.4 | 5.20 | 471 | 425 | 121 | 7.0 | 134 | 6.5 | 127 | 5.4 | 125 | 4.9 |
| Med. $SO_2$ | 128 | 72.1 | 5.19 | 1,243 | 979 | 125 | 7.0 | 141 | 6.6 | 123 | 5.8 | 125 | 4.9 |
| High $SO_2$ | 128 | 69.9 | 5.48 | 2,213 | 1,919 | 114 | 6.8 | 129 | 6.7 | 119 | 6.0 | 114 | 5.2 |

**TABLE 4**

**Effect of storage temperature and storage times on the acceptability of dehydrated sweet corn**

| Storage temp. | Total samples | Initial vacuum oven moisture (raw product) | Moisture content of dried corn | Original $SO_2$ | 6 mo. $SO_2$ | Initial exam. | | 1½ mo. exam. | | 3 mo. exam. | | 6 mo. exam. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total hydration after cook. | Organoleptic | Total hydration after cook. | Organoleptic | Total hydration after cook. | Organoleptic | Total hydration after cook. | Organoleptic |
| Average values | | | | | | | | | | | | | |
| °F. | | % | % | *p.p.m.* | *p.p.m.* | *g.* | | *g.* | | *g.* | | *g.* | |
| 70 | 128 | 71.8 | 5.27 | 972 | 992 | 119 | 6.3 | 123 | 6.6 | 128 | 6.0 | 125 | 5.7 |
| 85 | 128 | 71.8 | 5.27 | 1,013 | 991 | 123 | 6.4 | 142 | 6.6 | 125 | 6.2 | 124 | 5.2 |
| 100 | 128 | 71.8 | 5.27 | 972 | 815 | 123 | 6.4 | 127 | 6.4 | 118 | 5.2 | 116 | 4.3 |
| 115 | 128 | 71.8 | 5.27 | 970 | 524 | 119 | 6.6 | 126 | 5.2 | — | 3.3 | 108 | 2.9 |

**TABLE 5**

**Effect of the combination of sulfite levels and storage temperatures on the average initial and six-month organoleptic values**

| Combination of conditions $SO_2$, storage temperatures | Total samples | Average initial organoleptic score | Average 6-month organoleptic score |
|---|---|---|---|
| No × 70° F. | 32 | 4.6 | 4.2 |
| Low × 70° F. | 32 | 6.8 | 6.2 |
| Medium × 70° F. | 32 | 6.8 | 6.0 |
| High × 70° F. | 32 | 7.1 | 6.3 |
| No × 85° F. | 32 | 4.9 | 3.7 |
| Low × 85° F. | 32 | 7.1 | 5.5 |
| Medium × 85° F. | 32 | 7.1 | 5.9 |
| High × 85° F. | 32 | 6.5 | 5.6 |
| No × 100° F. | 32 | 5.1 | 3.1 |
| Low × 100° F. | 32 | 6.9 | 4.0 |
| Medium × 100° F. | 32 | 6.8 | 4.7 |
| High × 100° F. | 32 | 6.7 | 5.2 |
| No × 115° F. | 32 | 4.9 | 2.1 |
| Low × 115° F. | 32 | 7.1 | 2.6 |
| Medium × 115° F. | 32 | 7.2 | 3.2 |
| High × 115° F. | 32 | 7.0 | 3.7 |

A measure of maturity of raw sweet corn was given by vacuum oven moisture determinations. Moisture content of the raw corn varied from 65.9 to 79.6% within the 64 dehydration runs that comprised the experiment. The average moisture value for all samples included was 71.8%. The effect of variation of maturity on the initial and 6-month organoleptic values was evaluated by analysis of covariance. This analysis showed that maturity, as evaluated by vacuum oven moisture, indicated nothing about initial organoleptic values and little (not reaching the 5% significance level) about 6-month organoleptic scores. Therefore, it must be concluded that, under the conditions of this experiment, maturity variation of the raw product did not produce any significant effect on the acceptability of the finished product.

No effect of practical importance was found among the factors of water- or steam-blanching and long- or short-time blanching. However, cob blanched samples were found to be significantly more acceptable than cut corn blanched samples at the initial examination (Table 6). This condition was reversed and cut corn blanched samples were generally superior after 6-month storage, especially at higher storage temperatures. This probably reflects the differential absorption of sulfur dioxide between cob and cut corn blanched products rather than an essential difference shown by methods of blanching. The cut corn blanched product is acceptable both initially and after 6-month storage, provided an excessive amount of sulfite is not used.

The reversal of acceptability of cob corn over cut corn after 6-month storage at 100° F. and 115° F. may be attributed either to leaching effects or to differences in sulfur dioxide content. The Western Regional Research Laboratory *(4)* has found that a product subjected to considerable leaching during preparation was characterized by greater storage stability. Perhaps the explanation for this phenomenon centers around the fact that a product in which considerable leaching of soluble materials has occurred contains a lesser amount and possibly not the ideal combination of ingredients to foster the chemical browning reaction. This explanation appears plausible when applied to the dehydrated corn samples. It is commonly accepted that corn blanched on the cob is subjected to less leaching, with subsequent higher retention of soluble solids and flavor constituents. It seems reasonable that the medium is better for the chemical browning reaction in the cob blanched corn. Hence, it might be expected that the acceptability of a product treated in this manner would be less after 6 months' storage at relatively high temperatures.

As stated previously, the cob corn samples absorbed less sulfur dioxide during the sulfite treatment than did similar cut corn samples (Table 6). The lower sulfur dioxide concentration may have contributed to the increased acceptability of the cob blanched samples at the initial examination. However, the higher sulfur dioxide levels increased stability in the corn samples held 6 months at temperatures of 100° F. and 115° F. Therefore, it is not possible to resolve completely the issue of high initial acceptability of cob blanched corn samples which was reversed after 6 months' storage at 100° F. and 115° F. It is also evident within this experiment that the effects of the factors of cob versus cut corn may be dominated and practically concealed by differences of sulfur dioxide concentration.

No significant difference was found among samples dehydrated by the through and cross flow methods, although the average organoleptic scores favored the through flow products. The interaction of the effect of dehydration conditions and storage temperature resulted in significant differences (barely reaching the 1% level) in favor of through flow when the samples were subjected to high storage temperatures. The average sulfur dioxide concentration of the through flow dehydration samples was somewhat higher than that for the cross flow products initially and after 6-month storage. Although this difference in sulfur dioxide level is not large, 200 to 300 p.p.m., it may have contributed to greater storage stability in the 6-month samples. The higher sulfur dioxide concentrations in the through flow dehydration samples may be the result of low drying temperatures. The 130° F. dry bulb temperature utilized in the through flow dehydrator resulted in

**TABLE 6**

**Effect of cob or cut corn blanch and storage times on the acceptability of the dehydrated sweet corn**

| Treatment | Total samples | Initial vacuum oven moisture (raw product) | Moisture content of dried corn | Original $SO_2$ | 6 mo. $SO_2$ | Initial exam. | | 1½ mo. exam. | | 3 mo. exam. | | 6 mo. exam. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Total hydration after cook. | Organoleptic | Total hydration after cook. | Organoleptic | Total hydration after cook. | Organoleptic | Total hydration after cook. | Organoleptic |
| | | Average Values | | | | | | | | | | | |
| | | % | % | p.p.m. | p.p.m. | g. | | g. | | g. | | g. | |
| Cob blanch | 256 | 71.0 | 5.63 | 704 | 580 | 113 | 6.7 | 128 | 6.3 | 110 | 5.1 | 111 | 4.5 |
| Cut corn blanch | 256 | 72.5 | 4.92 | 1,259 | 1,082 | 129 | 6.2 | 134 | 6.1 | 125 | 5.2 | 126 | 4.6 |

relatively slight heat damage or quality loss of the product during the dehydration process. However, the temperature used was too low for efficient operation, and the total time for the initial drying operation averaged about 5 hours. Dehydration times of 5-hour duration, if adopted on a commercial scale, might also offer serious microbiological problems. No other significant effect of dehydration method, either singly or in combination with other preparation variables, was found when the initial and 6-month organoleptic data were analyzed statistically.

Cross flow dehydration which utilized initial dry bulb temperatures of 220° F. resulted in visible heat damage to a few kernels that were in contact with the metal tray or directly in the path of the air stream. Initial temperatures above 190° F. used for cross flow dehydration were undesirable and did not reduce the total drying time. Finishing temperatures of 160° F. were apparently satisfactory for cross flow dehydration.

The dehydrated sweet corn containing high moisture was significantly superior to the corresponding low moisture samples initially. Apparently this resulted from increased deterioration which occurred during the finish-drying of sweet corn to the lower moisture levels. However, after 6-month storage at elevated temperatures the low-moisture products were generally superior. The 6-month organoleptic examination revealed a significant interaction between storage temperature and high or low moisture levels in the dried product. Apparently the increased stability of the low moisture samples more than offset the initial disadvantage when storage temperatures were 85° F. or above.

The "dummy comparisons" (Table 1) include comparisons of samples marked for storage at different storage temperatures but never stored. Some of these proved statistically significant. For example, storage temperature had an apparent interaction with storage gas which was significant beyond the level of 0.001. No explanation but errors of random sampling can be offered, the alternative that one of the 3 aliases of this interaction is significant being entirely discordant with the other results as to significant main effects.

Some workers *(8)* have indicated that correlation exists between rehydration and degree of product deterioration of certain dried vegetables. In this study a careful examination of total rehydration values may appear to show certain slight downward trends in the amount of water uptake as storage period increases (Tables 2, 4, 6). These trends are slightly more pronounced with some factors, such as storage temperature and moisture content of the finished product. However, the statistical analysis showed no significant relationship among the main effects or first-order interactions. These results indicate that no substantial relationship exists between rehydration of sweet corn and preparation conditions or storage factors. Perhaps if the rehydration technique were more rigorously controlled, certain relationships might become evident. The United States Department of Agriculture Vegetable and Fruit Dehydration Bulletin *(8)* lists a number of sources of error that may be found in a rehydration procedure. Among the suggested errors, the time and temperature of cooking is considered critical. In the work reported here it was found difficult to control precisely the time required to bring the corn and water to the boiling temperature. This difficulty may have contributed some error to the rehydration data.

## SUMMARY

A fractionally replicated experiment was used to determine the effects of 6 preparation and 3 storage variables on the acceptability of dehydrated sweet corn.

Sulfur dioxide content of the product was found to be the most important single variable, and the effect of sulfite was evident directly and indirectly with several interacting variables.

Storage temperature exerted a very strong effect, especially at 100° F. and 115° F. and after 3- and 6-month holding periods. Moisture content of the dehydrated product had a significant effect initially and interacted with several other variables after 6-month storage.

Significant interactions were found between sulfite level and storage temperature, moisture of dried corn and storage temperature, cob or cut blanch and storage temperature, and between dehydration conditions and storage temperature after 6 months' storage time.

Of the several different conditions included in this study, the best combination for sweet corn dehydration would appear to include the following sequence of steps: (1) cutting the corn from the cob, (2) blanching 2 minutes at 210° F., (3) treating with sulfite to develop about 2,000 p.p.m. sulfur dioxide in the dry product, (4) dehydrating in a through-flow drier, (5) finish-drying to a moisture content of 5%, (6) hermetically sealing the product in a plain tin can. Our data indicate that this procedure will yield a dehydrated sweet corn which will remain acceptable after 6-month storage at 100° F.

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# The Maillard Reaction in Flesh Foods[a]

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**Methods of determining Maillard browning in white fish muscle and of determining both free glucose and ribose in flesh foods are described. Evidence is presented which indicates that only the free and not the combined ribose in fish muscle takes part in Maillard reactions. It is shown that there is a relation between added ribose and the degree of browning in fish muscle and also between the indigenous ribose content and browning of the muscle of different varieties of fish. About five times as much glucose as ribose is required to cause the same degree of browning in fish flesh. It is shown that the free ribose and glucose content of different varieties of fish, and of beef, pork and veal is very variable, and that free ribose is only formed post mortem in fish muscle. The amount of ribose formed at 0° C. by fish and meats from added ribonucleic acid, ribotides, ribosides, adenosinetriphosphate and ribose-5-phosphate is recorded. Fish muscle forms ribose from all these substrates, beef and veal only from ribosides and ribose-5-phosphate and pork only from the last named compound. The enzymic formation of ribose in fish muscle is discussed with special reference to the riboside hydrolases concerned. The glucose and ribose content of meats is usually such as to indicate that significant Maillard reactions would occur only on extended heating, but no quantitative method of determining browning in these darker flesh materials was available. Physical methods of removing ribose from fish muscle as well as the possibility of destroying it enzymatically are discussed.**

Little published information appears to be available concerning the occurrence of Maillard reactions in flesh foods which have been subjected to heat treatment, dehydration or both. Kaufman *(5)* stated that reactions of this type do occur in such foods, but neither described specific instances nor the mechanisms involved. Previous work by the writer *(8)* showed that the brown discoloration which developed frequently when the flesh of white fish was heated at 120° C. for one hour was apparently due to Maillard reactions, but the nature of the substance which contributed the aldehyde group was not determined. Further investigation showed that free D-ribose is, in most instances at least, the limiting factor in occasioning Maillard reactions in heated fish muscle *(9, 11)*, and the suggestion was made that this sugar arose through enzymic degradation of the nucleic acid of Hamoir's nucleotropomyosin *(2, 3)*. The occurrence of ribose as well as glucose in samples of beef and veal was also reported, as was the ability of the muscle tissues of certain fish to form D-ribose from added ribonucleic acid, ribotides and ribosides *(10)*. It is interesting to observe that in 1921 Berkeley *(1)* found that muscle tissue of certain fish contained from 350-410 μg. per g. of pentose. Since his samples were extracted with alcohol, free ribotides, ribosides and pentose would all have been accounted for. The present report deals with the post mortem occurrence of ribose and glucose in certain flesh foods; and more specifically with the formation of the first-named sugar in these foods, its role in occasioning Maillard reactions in fish flesh and with possible procedures for overcoming these reactions.

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## METHODS

The brown discoloration which occurred on heating fish flesh at 120° C. for one hour in an autoclave was determined quantitatively as follows. The cooked flesh was packed tightly into small dishes so that the surface was as level as possible and of uniform colour. The percent reflectancy of the sample was then referred to that of an arbitrary standard prepared by blending together 2.5% of block magnesium carbonate and 4% of high viscosity carboxymethylcellulose (Hercules) in water. The percent reflectancy of each sample was referred to that of the standard set at 100%, using a reflectance accessory with a Beckman model DU spectrophotometer and a wavelength of 500 mμ.

The total ribose content of fish muscle was determined using trichloracetic acid extracts and the Mejbaum orcinol reaction, as described by Hamoir *(2)*. The method used for determining free ribose in initial experiments was described previously *(11)*. The following technique, employed in the present experiments, proved equally accurate, much more rapid, and permitted determination of both ribose and glucose. The flesh sample was blended with 9 volumes of 95% or absolute ethanol, or, in cases where the ribose or glucose content of samples was high, mixing with an equal volume of alcohol, and centrifuging proved satisfactory. With the first modification the blended mixture was filtered and 30 ml. evaporated to dryness in vacuo over $H_2SO_4$. The residue was mixed well with 1 ml. of cold water. It was found convenient to "spot" .01 ml. portions of this solution at 3 cm. intervals on Whatman No. 1 filter paper for chromatography, though, in a few instances where the sugar content was low, .02 ml. amounts were spotted in two separate additions. The papers were developed for 16 hours at room temperature with ethyl

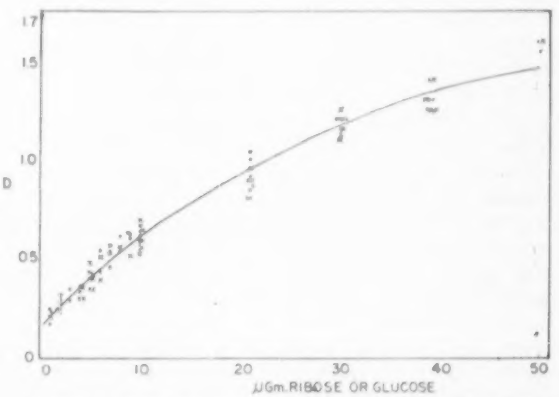


**Figure 1. Curve for direct determination of ribose and glucose using a "spotometer." Glucose — x and Ribose — · applied singly or as mixtures. D (which denotes optical density) = $\log_{10}$ (I₀/I).**

acetate : acetic acid : water solvent [Jermyn and Isherwood *(4)*], dried at room temperature, sprayed with aniline hydrogen phthalate solution *(7)* and heated 5 minutes at 105° C. to develop colour in the areas containing ribose and glucose. The papers were then cut lengthwise into strips 3 cm. wide so that the density of the coloured areas corresponding to ribose and glucose could be determined directly. It was found that this could be accomplished most conveniently by means of a "spotometer" [Paladini and Leloir *(6)*] used in a Beckman model DU spectrophotometer at 400 mμ wavelength and 2 mm. slit width. Figure 1 illustrates the standard curve used for both ribose and glucose determinations, the sugars being applied to the papers as solutions in 90% ethanol.

Though this method did not yield precise results it was found that usually ± 10% of added glucose or ribose could be recovered with muscle extracts prepared as above. From 0.25 to 0.5 μg. of the sugars could be detected visually on chromatograms, but, due to the variable absorbency of the filter paper itself (usually from about 0.025 to 0.125 density units), the spotometer could not be used with concentrations lower than about 1 μg. The most satisfactory range proved to be from 5 to 20 μg., and at these levels good recoveries of added ribose or glucose could be obtained if about 6 replicates were run. This technique has another great advantage over that previously employed, for alcoholic extracts of fish muscle contain varying proportions of ribosides which can be detected on the above chromatograms with ultraviolet light. In these chromatograms the zone corresponding to guanosine and cytidine (which have about the same $R_f$ value in this solvent) is not far separated from that of ribose, and care must be observed in cutting chromatograms for ribose elution not to include ribosides since these naturally give a positive orcinol reaction. This difficulty is overcome by the direct determination method.

The various substrates employed in the experiments concerned with ribose formation and the reference sugars used were Nutritional Biochemicals Corporation products.[b]

## RESULTS

**Relation between total ribose and browning.** Initial tests for total ribose in fish muscle indicated that there was no relation between this and the degree of brown discoloration caused by heating. The following experiments indicated that it was the free and not the total ribose which combined during heating of fish muscle.

Ten-gram portions of minced halibut muscle, which browned only slightly on heating at 120° C. for one hour (reflectancy value = 61% transmission), and of minced lingcod muscle which browned markedly during similar heating (reflectancy value = 39% transmission), were prepared both with and without 1500 μg. per g. of added ribose. The fish was heated in glass tubes at 120° C., samples being withdrawn at intervals of 1, 2 and 3 hours and the total ribose content determined. The results (Figure 2) showed that with halibut which contains little free ribose the total ribose content remained practically constant throughout the whole heating period, while that of the lingcod dropped during the first hour and thereafter remained constant. The average drop in total ribose in the lingcod muscle was 540 μg. per g. With both halibut and lingcod all the added ribose was removed within one hour. In a previous experiment carried out along similar lines but using only one hour heating, it was shown that the fall in the total ribose content of both halibut and lingcod

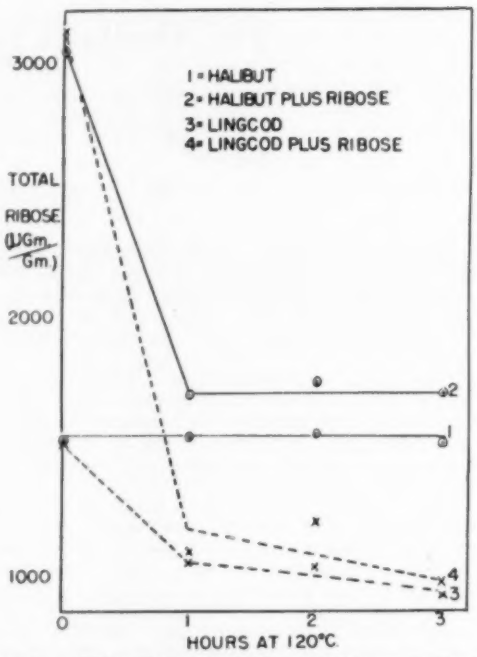


**Figure 2. Effect of heating halibut and lingcod muscle with and without 1500 μg. per grm. of added ribose, on total ribose as determined by the Mejbaum method.**

muscle was closely similar to the free ribose content as determined chromatographically employing the elution technique and the orcinol reaction *(11)*. It is assumed that free ribose combines with amino groups in Maillard reactions so that it can no longer be extracted with trichloracetic acid and determined by the Mejbaum reaction. An additional experiment showed that ribosides were unable to cause browning, for no decrease in reflectancy of halibut muscle was brought about by heating samples with uridine or guanosine in concentrations corresponding to 500 μg. of ribose per g. of flesh. It is of interest that the total ribose content of different samples of fish muscle has been found to vary from about 1500 to 3500 μg. per g.

**Relation between free ribose and glucose and browning in fish muscle.** The free ribose content of the muscle of different fish, and the degree of browning which occurred on heating samples of the muscle at 120° C. for one hour were determined. The results (Table 1) showed that there was a general tendency

**TABLE 1**

**Relation between Maillard browning and the free ribose content of different fish muscle samples**

| Species | Ribose (μg./g.) | % Reflectancy |
|---|---|---|
| Mullet (freshwater fish) | <10 | 69 |
| Halibut | 35 | 63 |
| Albacore tuna (fresh) | <10 | 57 |
| Albacore tuna (defrosted) | 32 | 56 |
| Albacore tuna (defrosted, stored 1 week in ice) | 29 | 59 |
| Bonito | 180 | 48 |
| Lemon sole | 140 | 40 |
| Skipjack tuna | 200 | 37 |
| Lingcod | 550 | 33 |
| Red cod | 240 | 28 |

[b] Mention of commercial products in the technical pages of this JOURNAL is for purposes of identification only.

for increased browning with an increase in the free ribose content. There was not an absolute agreement, but this can hardly be expected since Maillard reactions are complicated, and the rate of development of brown colour after the initial reaction of ribose and amino groups may not be the same with different muscle samples. That ribose and not glucose is the sugar mainly responsible for browning was shown by the following experiment.

Halibut muscle which contained 32 μg. per g. of free ribose and no appreciable glucose was heated at its natural pH with different amounts of ribose and glucose, and the reflectancy of the treated samples was determined. The results, given in Table 2, showed that about

TABLE 2

**Comparison of Maillard browning in halibut muscle occasioned by added glucose or ribose**

| Concentration of sugar added (μg./g.) | Percent reflectancy of heated samples | |
|---|---|---|
| | Ribose | Glucose |
| None | 67 | 67 |
| 50 | 65 | 66 |
| 100 | 62 | 67 |
| 200 | 59 | 67 |
| 300 | 56 | 67 |
| 400 | 53 | 64 |
| 500 | 47 | 61 |
| 1000 | 41 | 59 |

5 times as much glucose as ribose was required to occasion the same degree of browning.

Unfortunately no test has as yet been evolved which will permit the determination of browning in flesh of pigmented fish such as salmon or in meats. In salmon, tests indicate that the ribose and glucose content are such that they are unlikely to occasion serious Maillard reactions *(vide infra)*, and, indeed, there is little indication that such reactions occur to any significant extent in canned salmon. With meats the ribose content is almost invariably low, and the glucose content is usually not high enough to suggest that it may cause serious browning under the heating conditions used in these experiments.

**The ribose content of various samples of fish and meats.** The ribose and glucose content of the muscle tissues of a number of samples of fish and meats, some of well-defined history, was investigated, and the results are tabulated (Table 3). It will be seen that the muscle of living fish frozen in liquid nitrogen contained no appreciable free ribose or glucose, and that in one of the species studied there was rapid accumulation of both sugars post mortem at 0° C. The flesh of lingcod in rigor mortis also contained no appreciable ribose or glucose, and the former accumulated rapidly post mortem. The glucose content of lingcod flesh post rigor was low. Only small amounts of ribose occurred in the muscle of 3 of 4 species of salmon (genus *Oncorhynchus*) studied, but significant concentrations of glucose were present. Considerable variation in sugar distribution in the muscle tissues of tuna species and of bonito was observed. Both skipjack and bonito had rather similar concentrations of ribose and of glucose, while the remaining species had considerably less. The samples of pork studied were free, or almost free, of ribose. Their glucose content was very variable, in one instance exceeding 1900 μg. per g. Certain of the aged beef and veal samples contained ribose, but never in as high concentrations as those found in fish muscle. All beef and veal samples contained glucose in concentrations varying from 260 to 770 μg. per g.

**Formation of ribose from ribonucleic acid, ribotides, ribosides, ribose-5-phosphate and adenosinetriphosphate.** The formation of ribose from various nucleic acid fragments by muscle tissues was investigated in the following manner. Aqueous solutions of the substrates were prepared of such concentration that, if complete liberation of ribose occurred, there would be 2000 μg. of that sugar per g. of suspension when 0.5 ml. of the solution was incorporated in 1.5 g. of muscle. Where necessary the solutions were adjusted to about pH 7.0 with 1.0 N. NaOH. Barium was removed from barium ribose-5-phosphate solutions by addition of the

TABLE 3

**Ribose and glucose distribution in fish and meat [the figures in parentheses were obtained by the elution technique and orcinol reaction (11)]**

| | Sugar content (μg./g.)[a] | |
|---|---|---|
| | Ribose | Glucose |
| Albacore tuna (fresh) | <10 | 190 |
| Albacore tuna (defrosted) | (32) | — |
| Albacore tuna (defrosted, stored 1 week in ice) | 29 | — |
| Albacore tuna (dark lateral muscle) | 26 | <10 |
| Bluefin tuna (defrosted) | 40 | 52 |
| Skipjack tuna (defrosted) | 190 | 350 |
| Bonito (defrosted) | 180 | 310 |
| Coho salmon (fresh market sample) | 0 | 23 |
| Pink salmon (fresh market sample) | 20 (17) | 740 |
| Sockeye salmon (fresh market sample) | 30 (55) | 270 |
| Red spring salmon (fresh market sample) | 10 (16) | 290 |
| Lingcod (in rigor mortis) | 0 | 0 |
| Lingcod (same fish, muscle stored 20 hr. at 20° C.) | 880 | <10 |
| Sculpin 1 (live fish frozen in liquid nitrogen) | 0 | 0 |
| Sculpin 1 (muscle stored 2 days at 0° C.) | (604) (636) | 330 |
| Sculpin 1 (muscle stored 4 days at 0° C.) | 590 | 430 |
| Sculpin 2 (live fish frozen in liquid nitorgen) | 0 | 0 |
| Sculpin 2 (muscle stored 2 days at 0° C.) | 710 | 430 |
| Sculpin 2 (muscle stored 4 days at 0° C.) | 700 | 730 |
| Tomcod (live fish frozen in liquid nitrogen) | 0 | 0 |
| Tomcod (muscle stored 2 days at 0° C.) | 17 | 48 |
| Halibut (fresh market sample) | 42 (35) | 34 |
| Mackerel (California) | <10 | 450 |
| Red Cod (fresh market sample) | 310 (240) | 70 |
| Lemon sole (fresh market sample) | 120 (140) | 120 |
| Lingcod (fresh market sample) | (525) (585) | 30 |
| Pork (market sample of loin chop) | <10 | 170 |
| Pork (market sample of rib chop) | <10 | 1940 |
| Pork (loin chop stored 2 days at 2° C.) | 0 | 120 |
| Pork (loin chop stored 9 days at 2° C.) | <10 | 0 |
| Veal (shoulder chop, market sample) | 90 | 450 |
| Veal (rib chop, stored 2 days at 2° C.) | <10 | 370 |
| Beef tenderloin (market sample) | 91 | 680 |
| Beef wing steak (steer, stored 2 days at 2° C.) | 0 | 670 |
| Beef wing steak (cow, stored 2 days at 2° C.) | <10 | 700 |
| Beef front shank (stored 2 days at 2° C.) | <10 | 260 |
| Beef brisket (stored 2 days at 2° C.) | <10 | 610 |
| Beef T bone steaks (stored 2 weeks at 2° C.) | 200 | 770 |
| Beef round steak (market sample) | 125 | 550 |

[a] 0 = No detectable ribose on the chromatograms; <10 = trace of ribose which could not be determined accurately.

calculated quantity of $Na_2SO_4$, centrifuging and washing the precipitate in the usual manner. Adenosinetriphosphate was used as the sodium salt. Since certain of the substrates are sparingly soluble in water, it was necessary to heat their solutions and incorporate them

carefully in the chilled muscle samples so that the temperature of the mass would not be such as to destroy the enzymic activity. The muscle tissues were blended in the cold prior to use, 1.5 g. samples placed in 5 ml. beakers together with the substrate solution and stored at 0° C. for 3 or 5 days before determining the ribose content.

The results of this experiment (Table 4) show that fish muscle exhibited much more intense activity toward the various substrates as judged by ribose formation than did that of the mammals under the experimental conditions. The fresh lingcod was very active and formed ribose in approximately theoretical amounts,

**TABLE 4**

**Ribose formation by fish, beef, pork and veal from ribonucleic acid, ribotides, ribosides, adenosinetriphosphate and ribose-5-phosphate [a]**

| Substrate | Fresh lingcod [b] | Lingcod frozen 3 months at −20° C.[c] | Rock cod frozen 3 months at −20° C.[c] | Beef (mixed sample) [c] | Veal (mixed sample) [c] | Pork (Loin chop) [c] |
|---|---|---|---|---|---|---|
| None | 680 | 700 | 1060 | About 50 | About 50 | <25 |
| Adenosine | 2160 | 1920 | 1460 | 440 | 520 | None |
| Guanosine | 1600 | 920 | 720 | 200 | 250 | None |
| Inosine | 2170 | 1860 | 1620 | 470 | 350 | None |
| Xanthosine | 2150 | 1600 | −120 | 250 | 290 | None |
| Cytidine | 2000 | 1390 | 450 | <25 | <25 | None |
| Uridine | 1160 | 360 | 230 | None | None | None |
| Myoadenylic | 1900 | 40 | 1260 | None | None | None |
| Yeast adenylic acid | 1100 | 1020 | 800 | None | None | None |
| Guanylic acid | 860 | 830 | 340 | None | None | None |
| Cytidylic acid | 560 | 90 | 130 | None | None | None |
| Uridylic acid | 630 | 80 | −16 | None | None | None |
| Adenosinetri phosphate | 280 | −430 | 1140 | None | None | None |
| Ribonucleic acid | 1800 | 660 | 460 | None | None | None |
| Ribose-5-phosphoric acid | 440 | 390 | 180 | None | None | 460 |

[a] The results given for each substrate represent the difference between the amount of ribose formed from that substrate and the corresponding control. The fish samples had pH values ranging from 6.8-7.1 and meat samples 6.6-6.8 at the conclusion of the experiment.

[b] Samples stored 3 days at 0° C. before ribose determined.

[c] Samples stored 5 days at 0° C. before ribose determined.

within the probable limits of accuracy of the method of estimation, from adenosine, inosine, xanthosine, cytidine, myoadenylic acid and ribonucleic acid. The rather great insolubility of guanosine probably contributed to its slower breakdown. In general the ribotides, other than the muscle adenylic acid, were less rapidly broken down than the ribosides, and this was also true of ribose-5-phosphoric acid. The defrosted lingcod and rock cod muscle tissues generally exhibited lower activity than the fresh muscle sample, perhaps partly because of the shorter incubation time at 0° C. Some curious discrepancies were evident. Thus with the defrosted lingcod muscle adenosinetriphosphate actually hindered the formation of ribose from indigenous substrates, and this appeared to be true to a lesser extent with xanthosine in the case of the defrosted rock cod muscle. It is evident that with the fish muscle samples a complex of enzymes is involved in the formation of ribose, and the evidence indicates that ribonuclease, phosphomonoesterase, adenosinetriphosphatase and riboside hydrolase (or, possibly, riboside phosphorylase) enzymes may be included.

The beef and veal samples attacked the 4 purine ribosides and ribose-5-phosphate with the formation of a moderate amount of ribose, but the ribotides, ribonucleic acid and adenosinetriphosphate did not yield ribose under the experimental conditions. The pork muscle did not form appreciable amounts of ribose from any of the substrates studied except ribose-5-phosphate.

A study of the enzymes concerned in the degradation of ribonucleic acid and its various derivatives is being carried out with preparations made from fish muscle *(10)*. Protein fractions with about 50 times the activity of the whole muscle toward inosine and adenosine have been obtained from both lingcod and rock cod. One of these fractions caused ribose formation only from purine ribosides, while another attacked both the purine ribosides and the pyrimidine riboside cytidine, but not uridine. So far attempts to demonstrate the presence of a riboside phosphorylase have not been successful, and it would seem possible that only nucleoside hydrolyase enzymes are involved in the formation of ribose from nucleosides by fish muscle. The work on enzyme fractionation is proceeding.

**Prevention of Maillard reactions.** Several possible methods of preventing or diminishing the severity of Maillard reactions in fish muscle suggest themselves. It was shown some time ago that leaching raw flesh in cold running water would eliminate the browning which occurred on heating it at 120° C. for one hour *(8)*. If the flesh is heated to a sufficient extent to coagulate the proteins, browning can be reduced due to loss of expressed liquid, but, since ribose probably combines with amino groups of the muscle proteins, and some of the liquid usually remains, browning will probably not be entirely eliminated. These leaching and heating methods may result in loss of desirable flavour constituents. It is possible that if fish flesh could be heated while still in rigor when free ribose has not formed Maillard reactions could be eliminated.

The most attractive way of overcoming browning in heated or dehydrated fish flesh would be the removal of free ribose by enzymic means, a method which appears to have proven successful in removing glucose from eggs to prevent Maillard reactions in the dehydrated product. At present a search is being made for an enzyme preparation which will render ribose inactive as far as the Maillard reaction is concerned. It has been found that lager beer yeast, *Lactobacillus pentoaceticus, Acetobacter suboxydans, Penicillium notatum, P. chrysogenum, Fusarium redolens* and *F. solani* all grow upon media containing ribose and decompose the sugar. Some exploratory work has been carried out with a view to obtaining an enzyme preparation which will possess activity sufficient to oxidize or otherwise remove ribose from fish muscle. This work is proceeding.

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# Some Recent Developments in Aluminum Foil Packaging of Foods[a]

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In describing recent aluminum foil developments, discussion will center on the metal generally described as foil analysis aluminum. This grade contains a minimum of 99.35% aluminum with the major portion of the remainder consisting of iron and silicon. Normally, this is the metal used for the manufacture of foil because it gives a better end product and is easier to roll than aluminum that contains a high percentage of impurities. There are occasions where alloyed aluminum is used, but these occasions are currently the exception, rather than the rule. Undoubtedly, alloys for foil will be considered more and more in the future as the demand and requirements increase, but the subject matter of this paper will concern aluminum foil as most people in the food field know it.

Aluminum foil is manufactured using a cold rolling process. As it is rolled down to thinner gauges, it becomes work hardened to an increasing degree because of the fact that the aluminum crystals or grains are put into a highly strained and stressed state. Consequently, when the foil you normally see comes off the rolling mill, it is fairly brittle and contains residual rolling oils on the surface. At this point, the foil has its highest tensile strength—approaching 25,000 pounds per square inch, but for most food packaging, it has certain specific objectionable properties, all of which can be overcome by a relatively simple procedure. These objectionable properties are the oily surface and the hardness. The oily surface makes it difficult to obtain adhesion regardless of whether the material you are trying to adhere is an ink, coating or another web material. The fact that the sheet is hard makes it difficult to handle in packaging operations. The method by which both of these objectionable properties are overcome is through an annealing process. The foil is heated to a temperature somewhat below its melting point. The highly work hardened grains are re-crystallized into a new essentially strain and stress free state. The foil, as a result of this re-crystallization, becomes very soft and flexible. By allowing the foil to remain at the elevated temperature for a long enough time, the residual oils are volatilized or burned from the surface. The surface thus becomes quite dry and is wettable with practically any liquid-water included—and adhesion becomes a relatively simple problem. For most food packaging applications, it is this type of aluminum with which we are concerned. (Figures 1 and 2).

**Figure 1. Among many other product uses, aluminum foil has found many applications in the baked products field.**

## PACKAGING APPLICATIONS

**Foil-paper applications.** In most packaging applications, the desirable properties of aluminum foil are best utilized by combining it with another material such as paper or a plastic film. Because of the various papers having been available and utilized for a much longer period of time than the plastic films, some of the things that have been done through combining aluminum foil and paper will be of interest.

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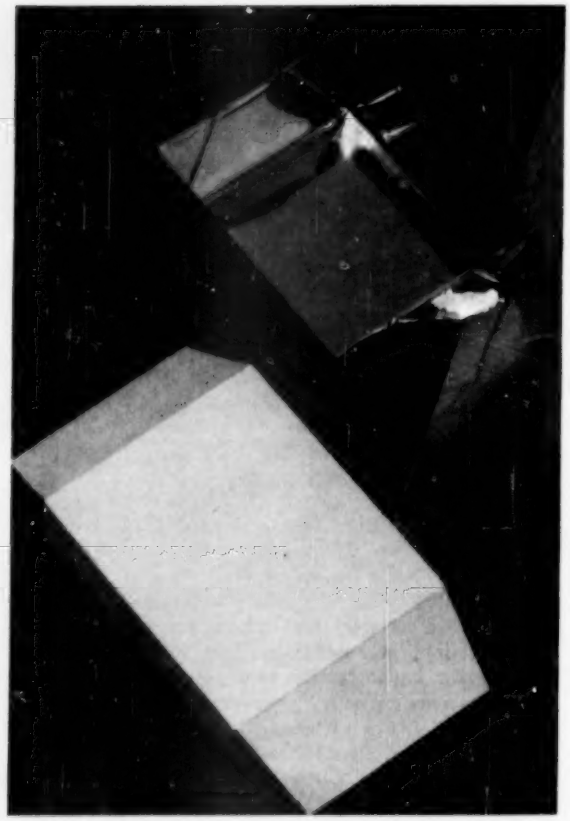

**Figure 2. The application of aluminum foil to the packaging of frozen or refrigerated products has grown rapidly in recent years.**

There are somewhat over 45 standard production papers and these can really run into an almost infinite number through making slight weight changes in them. Actually, there are very few, if any, of these that are not used in the food packaging field. This list includes such papers as bonds, bleached and unbleached krafts, tissues, glassines, parchments, and on through label papers, litho papers and boards. There is space to discuss only some of the applications of parchment, wet strength tissues, and very porous tissues when combined with foil.

Following World War II, there was undertaken the development of a butterwrap that would offer butter protective packaging not available from paper alone. At least 30 foil paper combinations were included in the original investigation with a number of them showing considerable promise. As a matter of fact, several of these specifications gave satisfactory results, but the one that was finally adopted was a rather complicated structure. In spite of this, it had several safety factors built in and for that reason, it was felt advisable to start out with the best and then through experience to work down to more economical available materials. This original specification consisted of a light weight parchment, wax mounted to .00045 aluminum containing a protective vinyl coating on both sides of the foil. The parchment was used because of its known background. It does not adhere to, or defiber in contact with, butter, and in addition, experience has proven that it gives no foreign taste to the butter. A straight unplasticized vinyl coating was used on both sides of the foil because of the fact that this was the most protective available resin that could be used for this purpose. The wax was used for joining the coated foil to the parchment paper. Such a product as this was put through very exhaustive tests through the cooperation of one of the largest butter manufacturers in the country, and results of these tests indicated that the foil wrap would maintain the score of the butter for a period of time far in excess of any practical wrap available heretofore. For example, 92 score butter packaged in this foil wrapper would maintain the score of the butter for longer than two weeks at a temperature of 70° F.

Immediately after the adopting of this wrapper by some of the butter manufacturers, work was instigated to come up with a more economical material that would do a job equal to the specification described above. One of the first improvements made was the alteration of the vinyl coating on the side of the foil toward the product to make this a combination coating and thermoplastic adhesive. This would allow the omission of the wax laminant and would reduce the manufacturing operations in number by one. It was also found through tests that the thickness of the protective foil could be reduced from the .00045 gauge all the way down to .00035 without reducing the protective qualities of the wrapper. Actually, in introducing this to the field, the movement from .00045 down to .00035 was by degrees in order to take the least amount of chance on running into some unforeseen difficulty in the field. Before getting down to the .00035, .0004 foil was used for months while the .00035 was being market tested.

That difficulties can be encountered in the field is shown by the following unfortunate circumstance. A material consisting of a foil tissue combination, the surface being treated with a grease resistant material, was subjected to all kinds of laboratory tests. Material used in these laboratory tests was all produced on production equipment. It was assumed that there would be enough representative variations in the material to cover all circumstances that could be encountered in the field. About the time of the completion of the laboratory tests, difficulty was encountered in obtaining the then currently used parchment paper (due to a strike or an anticipated strike) and a considerable number of wrappers as described above were produced and put into the field. Trouble was encountered. The grease resistant coating either in its grease resistance or a variation in application fell down with the result that the tissue paper defibered and the individual fibers got onto the butter, making it unappetizing, to say the least.

The most recent work on an economical butter wrap has been in the utilization of wet strength tissues. Some of these when combined with aluminum foil give a product that is considerably more satisfactory than a straight paper wrapper but somewhat inferior to the combination of aluminum foil and parchment. This is apparently due to the fact that the tissue is an absorbent sheet, and accordingly, through a wicking action, will absorb foreign odors and gradually transmit them into the butter. Both of these wrappers, that is, foil parchment and foil wet strength tissue, are being used today with an excellent degree of success, but with the foil parchment combination showing slightly better keeping quality results than does the foil wet strength tissue combination.

Probably one of the most widely observed foil packages in the grocery stores today is the gravure printed foil carton overwrap used for such products as cookies, cereals, peanut brittle, frozen fish, frozen shrimp, among others. The product used quite often is a combination of foil, paper and wax. On the particular product to which I have reference, there is a patent, but there are a number of licensees making this product which is known in the trade as Reyseal. The aluminum foil portion of the laminant is, of course, used for its functional properties. The other key part of the material is the combination of wax and a light porous tissue. There may or may not be an intermediate paper sheet depending on the finished properties such as strength and flexibility desired in the sheet. The simplest combination in this series of Reyseals is a light gauge foil laminated to a light porous tissue with a sufficient quantity of wax to effect a heat seal when the finished laminant is subjected to heat and pressure. The wax is generally of a tacky nature and the porous tissue is added to prevent blocking and to allow a flow-through of the wax when the wax is melted. Web materials such as the various plastic films, papers of all grades, and even non-woven cloth fabrics can be added as intermediate sheets,

that is, in between the heat sealing wax and foil to provide specific desirable properties. Materials as described above work on practically all conventional overwrapping machinery, and accordingly, present no problem in order to use it.

**Polyethylene.** Probably the most versatile material that can be used today in conjunction with aluminum foil is polyethylene. It, in itself, has rather unique properties and among other things, it is odorless, tasteless, non-toxic and also very important, it is relatively cheap. Like other products, it has properties that can be improved upon by combining it with other materials, and it is the properties of foil and polyethylene combined that I want to discuss a little.

First, in the line of applications with aluminum foil, it is used as an extruded hot melt for the lamination of foil to other web materials. In this case, paper would be given primary consideration as the material to combine with foil. The economies of the finished lamination play a large part in making such a determination. The purpose of the polyethylene in this case is to provide a film forming flexible adhesive that will fill the fractures that occur in the foil and accordingly, will keep the water vapor transmission of the finished laminate at a minimum. Polyethylene is being extruded commercially onto other materials at thicknesses down to ½ mil. The weight per ream 24/36/500 of polyethylene this thick is approximately seven pounds. Therefore, it can be seen that from an economical standpoint, this is a practical operation. On the water vapor transmission rate, a specific example of the effects of such a lamination can be demonstrated by comparing the results obtained on an aqueous glue mounted sheet with a polyethylene mounted sheet. A 15 pound tissue glue mounted to .00035 gauge foil and the same paper and foil combined with polyethylene will show a water vapor transmission rate of approximately 0.04 grams per 100 square inches per 24 hours as determined by the standard T.A.P.P.I. method on a flat sheet. But now comes the real difference. On a creased sheet, which represents what happens when a sheet is folded or handled, the water vapor transmission rate of the glue mounted sheet increases by approximately four times to 0.16 g. per 100 square inches per 24 hours. That of the polyethylene mounted sheet increases to approximately 0.07 g. Just how far this type of lamination is going to be used yet remains to be seen, but it is something that should be considered by every user of protective foil paper laminants to determine what they could gain through adopting such a structure.

The second current use of foil-polyethylene combinations is where the polyethylene is used primarily for its heat-sealing properties. The polyethylene is applied to the heat-sealing side of the foil laminant directly from the resin stage. It should be quite obvious that cost plays a prominent part in this case, because it has been necessary up until now to apply a film former to a foil material by one of several more expensive procedures. Commercially, the film formers have been applied from a solvent solution or by taking a preformed film—either extruded or cast—and laminating it through application of an adhesive. The economies involved on the polyethylene coated foil laminant result from the absence of solvents, since they are just a necessary evil to accomplishing either of the latter named procedures. Now, what do we get from such a product? Generally speaking, it has always been desirable to use a film of from ½ to 1 mil. in thickness as the heat sealing medium of a foil laminant or for just about any laminant for that matter. However, for many applications, the economies of a laminate using a film of such thickness has necessitated the use of a much thinner film applied from a lacquer solution. By so doing, it has been necessary to sacrifice some of the protective properties that would be desirable in the packaging material, and thereby, a second best package is put on the market. Again, as in the case of using polyethylene as a laminant, it acts to cover up fractures that occur in the handling of a light-gauge foil laminate. Here, also, it is well to use the water vapor transmission rates of some finished materials as illustrations. I shall overlook reference to plain or uncreased sheets in giving these water vapor transmission rates and cite results on creased sheets instead. A sheet made of a 30-pound bond paper laminated to .00035 foil with a film thickness of 0.1 mil. as the heat-sealing medium will show a water vapor transmission rate of approximately 0.11 g. The same sheet, but using a polyethylene film, ½ to 1 ml. in thickness, will give a water vapor transmission rate of about 0.04 grams.

The above references to water vapor transmission rates are perhaps most familiar as one of the starting points in evaluating packaging materials. However, there are other possible applications under very comprehensive study now using materials as described above. Some prospective uses that have given good preliminary results are gas packaging, vacuum packaging, and the packing of liquid or semi-liquid, in these flexible foil materials.

Pliofilm, Goodyear's trade name for their rubber hydrochloride film, is another material in the field of plastics that can be excellently utilized in illustrating how two materials combined together will overcome deficiencies in the individual materials. Foil by itself, as we all know, has no heat sealing properties. On the other hand, it is impermeable to gases; particular reference is made to nitrogen and water vapor. Pliofilm, of course, has excellent heat sealing properties but relatively poor gas permeability, that is, Pliofilm has a high nitrogen gas transmission rate in relation to foil, but it is low in comparison to most other heat sealing plastic films. Now the two combined result in a material that in the flat state has a zero transmission rate to both nitrogen and water vapor. Such a material when formed into a fin-sealed envelope maintains a low order of nitrogen and water vapor transmission; this material is being used today for the nitrogen gas packaging of activated dry yeast. Here the foil-pliofilm combination maintains for a considerable period of time an oxygen content of less than two per cent. In bringing out this low gas transmission property of this combination, mention should be made of Saran, Dow's trade name for the polyvinyldene chloride film. This material combined with foil also gives an excellent package in this respect.

## SOME CURRENT INTERESTS IN ALUMINUM FOIL PACKAGING

More and more aluminum foil, uncombined with other web materials, is being used for food containers. There are a number of tray type containers on the market that are being used in particular for prepared or cooked products. These containers are being used because of the efficiency obtained from the use of the container for the preparation, the reconstitution and serving of the food. Heat seal coated straight foil materials are being formed into fin sealed pouches and these are being used also for the reconstitution of foods. In this particular category, one of the biggest present obstacles to overcome is the application of a protective coating to the metal used for these tray-like containers that will resist attack by the various food products packaged therein. Efforts are being made in this regard, but currently each product must be checked to determine: First, if the product is going to attack the uncoated aluminum, and secondly, if it does, to determine which specific coating will offer protection to the aluminum.

# Color Changes in Packaged Bologna[a,b,c]

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(Manuscript received June 13, 1953)

**Color fading in sliced packaged bologna, studied by means of subjective evaluation and by reflectance measurements, is reported. Spectrophotometric reflectances at 650 mμ and 570 mμ for good and poor controls were employed for assigning scores to be used as standards for the color evaluations made by the judging panel. Transparent semi-moistureproof cellophane permitted greater discoloration of packaged bologna than was observed when the meat was wrapped with less transparent laminated materials having lower permeabilities to oxygen and water vapor. Laminated films did not prevent fading on exposure of bologna to display-case lights, but did keep the meat from darkening. Cellophane permitted appreciable desiccation, resulting in an undesirable dark brown color when weight losses of bologna were greater than 10%. Noticeable fading of packaged bologna occurred after about 1 hour under Soft White fluorescent light at an intensity of 60 footcandles. Evacuation of the packages resulted in less pronounced discoloration than that observed when air was not excluded. Ultraviolet light was shown to produce less harmful effects on the color of bologna than were noted when Soft White fluorescent light was used for display of the meat. Better color retention under ultraviolet light may have been due to high absorption of ultraviolet radiation by the packaging materials, thereby reducing the light intensity at the meat surface.**

Self-service merchandising, a recent development in retailing meats, has brought several problems into recognition—among these is the discoloration of cured meats packaged for this form of merchandising. Change of color is one of the major technical difficulties associated with this rapidly expanding retailing method *(2, 8, 9, 12)*.

High intensities of light in display cases have been cited by Hockman *(4)* and Pracejus *(6)* as increasing the sales appeal of packaged meats but, as a counter-effect, adding to the color-fading problem. In tests with sliced bologna, one of the meats most susceptible to the action of light, Taylor and Pracejus *(10)* observed perceptible color change with an exposure of approximately 150 to 200 footcandle-hours when the meat was held under tungsten-filament or "Soft White" fluorescent lamps. A display period of 2 to 3 hours was considered sufficient to bring about fading. Ramsbottom *et al. (9)* indicated that a shorter time of exposure caused fading of bologna and other cured meats; discoloration occurred after display for one hour at an intensity of 60 foot-candles of Soft White fluorescent light. Fading was more rapid and more pronounced when the light intensity was 60 instead of 20 footcandles.

Several investigators *(1, 4, 12)* believed the effect of light in producing color fading in cured meats could be minimized by filtering out wavelengths considered to be most harmful. Urbain and Ramsbottom *(12)* indicated the use of red cellophane for wrapping cured meats permitted greater color retention than that noted when a material transparent to all wavelengths was employed. However, Allen *(1)* found different portions of the visible spectrum produced equal fading of sliced bologna when the light intensity was held constant. The ultraviolet energy radiated by fluorescent lamps was shown by Taylor and Pracejus *(10)* to play only a minor role in fading colored materials; they concluded that fading was due principally to radiation in the visible spectrum. Tungsten-filament and Soft White fluorescent lamps were demonstrated to have about equal ability to cause fading of sliced bologna. Sliced cured meats exposed to germicidal ultraviolet radiations by Ramsbottom *et al. (9)* did not exhibit as marked discoloration as did similar meat items stored under Soft White fluorescent light at an intensity of 60 footcandles.

The role of atmospheric oxygen in the discoloration of cured meats was demonstrated by Urbain and Jensen *(11)*. In studying color changes in sliced boiled ham, Urbain and Ramsbottom *(12)* found color retention was best secured by exclusion of oxygen or by elimination of light. Since transparency of materials is requisite for self-service merchandising, vacuum-packaging has been indicated *(3, 12, 13)* as an effective means of preserving color. Consideration was given by Ramsbottom *et al. (9)* to the use of packaging materials having low permeability to oxygen in preventing discoloration of cured meats.

## EXPERIMENTAL PROCEDURE

Large bologna was sliced at the time of purchase with a U. S. Slicing Machine Company meat slicer set at No. 5 (corresponding to a slice thickness of 0.115 to 0.120 in.). The meat was transported to the laboratory and 2 or 3 slices each were packaged in bags made from the following materials: 300-gauge LSAT cellophane, 300-MAT-2 cellophane laminated to 200-gauge polyethylene, and 300-MAT-2 cellophane laminated to 100-gauge Saran. Packages were heat-sealed and stored in a Percival open-type meat display case at 2.5° C. ± 1°. During the daily defrosting period, the temperature rose to 10° C., but in no instance did it remain above 3.5° C. for longer than 2 hours.

Relative humidity in the display case was measured with a Cenco Hygrograph, and ranged from 40 to 75%.

General Electric 15-watt Soft White fluorescent and germicidal ultraviolet lamps were mounted in the display case at a distance of approximately 30 inches from the trays used to support meat packages. Light intensity was measured in footcandles by means of a General Electric exposure meter (type DW-68); different intensities were obtained by placing the packages at various locations on the trays.

For vacuum-packaging, slices of bologna were placed in bags which were then heat-sealed to one-hole rubber stoppers fitted with glass and rubber tubing and a protective layer of Tackiwax

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[b] This work was supported, in part, by a grant from Armour and Company, Chicago, Ill.

[c] Presented at the Thirteenth Annual Meeting of the IFT, Boston, Mass., June 22, 1953.

applied. Details of the general procedures used for evacuation were described by Ogilvy, Burke, and Ayres *(5)*.

In all trials, samples were removed periodically from the display case and color was evaluated subjectively by a panel of 6 judges and objectively by reflectance measurements. A Beckman Model DU Spectrophotometer with diffuse reflectance attachment *(7)* was employed for reflectance determinations in the region between 540 and 800 mμ; a block of U. S. P. Carbonate of Magnesia served as the standard. Samples designated as *good* controls were packaged with the laminated materials previously described, over-wrapped with aluminum foil (0.0015 in.) and stored in the lower section of the case under a sheet of black paper. In order to maintain circulation of air over the samples, the black sheet was supported a few inches above the upper surface of the packages. *Poor* controls were wrapped with LSAT cellophane and placed in the case under Soft White fluorescent light 3 to 5 hours in advance of other packages. Scores for *good* and for *poor* controls were assigned in accordance with the values obtained for the ratio of spectral reflectance at wavelengths 650 and 570 mμ, a ratio proposed by Ramsbottom *et al. (9)* as an index of color fading. Reflectance ratios (650/570 mμ) and corresponding scores for controls were designated as follows: 2.50, 10; 2.35, 9; 2.20, 8; 2.05, 7; 1.90, 6; 1.75, 5; 1.60, 4; 1.45, 3; 1.30, 2; 1.15, 1. The upper limit of 2.50 for the reflectance ratio was adopted from the highest value given by Ramsbottom *et al. (9)* for fresh sliced bologna, and the lowest value of 1.15 was determined by preliminary tests on bologna stored for 9 days.

It was believed that the reflectance ratio would provide an objective measurement of the high and the low standards used for subjective estimation of color. The use of such an objective method was considered to be of value in establishing reproducible limits for the scores given by the judging panel.

For visual evaluation of color, a judging booth having dimensions 24″ x 30″ x 41″ was equipped with a 200-watt Sunshine Lighting Unit (UCD-ADD-30) manufactured by the Keese Engineering Company. The illuminant provided a light intensity of 100 footcandles on the inspection table in the booth.

Transmission of light by packaging materials was measured by means of the spectrophotometer with hydrogen-discharge and tungsten-filament lamps in the ultraviolet and visible regions of the spectrum respectively. Folding or wrinkling of materials was prevented by placing a silica glass absorption cell between the surface of the packaging films and the wall of the cell holder; an absorption cell with no wrapping material was used as the blank.

Changes in weight of packaged samples were determined with a torsion balance having a sensitivity of 2 mg.

## RESULTS AND DISCUSSION

Measurements were made of the spectral reflectance of 18 slices of freshly cut bologna in order to determine the variation among samples before storage. Mean reflectance values and confidence interval estimates are presented in Table 1.

**TABLE 1**
**Spectral reflectance of freshly sliced bologna**
**$MgCO_3 = 100$**

| | Wavelength (mμ) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 540 | 570 | 600 | 650 | 700 | 750 | 800 |
| Mean | 27.86 | 28.00 | 38.61 | 62.22 | 67.36 | 67.31 | 67.42 |
| Confidence interval ($P = 0.05$) | 27.17<br>28.63 | 27.23<br>28.77 | 37.67<br>39.53 | 61.13<br>63.27 | 66.22<br>68.58 | 66.11<br>68.49 | 66.13<br>68.67 |

Inspection of these data revealed that the reflectance properties of fresh slices of bologna purchased on different days did not vary to an appreciable extent, indicating that only slight differences existed in color of samples at the initiation of each experiment.

As indicated in Figure 1, LSAT cellophane transmitted a higher proportion of light than did either polyethylene laminated to cellophane or Saran laminated to cellophane. LSAT cellophane showed a rather sharp decline in transmission in the region below 380 mμ, while the less transparent laminated materials demonstrated a more gradual cut-off. Since fading is proportional to light intensity, it may be expected that the use of highly transparent wrappers would result in rapid discoloration of cured meats packaged with such materials and exposed to light. With all materials tested, the amount of visible light transmitted was greater than that of ultraviolet light. The absorption of ultraviolet radiations by wrapping materials reduced the intensity of ultraviolet light incident to the surface of packaged meats.

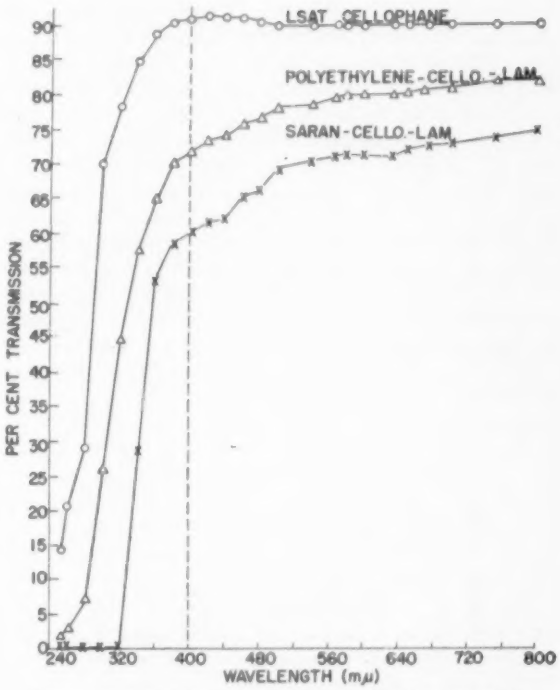


**Figure 1. Transmission of light by packaging materials.**

In addition to transparency, other properties of packaging films of importance in discoloration of self-service cured meats include permeabilities to oxygen and water vapor. The influence of these factors on discoloration of bologna packaged with LSAT cellophane and with the polyethylene-cellophane laminate is demonstrated in Figures 2 and 3. Little difference was observed in judging scores for meat displayed under 35 to 55 footcandles of Soft White fluorescent light for 1 and 3 days; bologna wrapped with the laminate was scored higher after storage for 5 and 7 days than was similar meat packaged with LSAT cellophane. At the end of one day in storage, the ratio of reflectance at 650 mμ to reflectance at 570 mμ was higher for bologna packaged with the cellophane than it was for meat wrapped with the laminate, and increased during further storage. Increase in reflectance ratio may have been caused by browning of the meat packaged with LSAT cellophane; although reflectance in the range 540 to 800 mμ (Figure

3) showed a decline, the ratio of values at 650 mμ to those at 570 mμ became higher (Figure 2). On the other hand, changes in reflectance of bologna wrapped with polyethylene laminated to cellophane were negligible after initial fading occurred. With both packaging materials, the most rapid fading took place during the first day of exposure to light. At the end of one day, samples were described as faded pink in color; bologna packaged with LSAT cellophane appeared slightly darker than that wrapped with the laminate. During additional storage, meat wrapped with cellophane continued to darken and presented a dark brown appearance at the end of the seventh day of display. Bologna packaged with the polyethylene-cellophane laminate was described as faded brown in color after a similar period of storage.

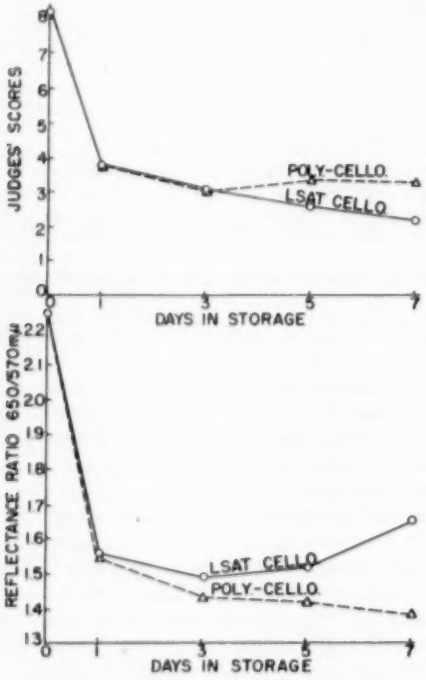


**Figure 2. Relation of packaging materials to judges' scores and reflectance ratios of bologna exposed to 35-55 footcandles of Soft White fluorescent light.**

Differences in color changes of bologna packaged with the above materials may be ascribed, in part, to dehydration. Weight losses of samples are illustrated in Figure 4. LSAT cellophane permitted appreciable desiccation to occur; at the end of 3 and 5 days, bologna lost about 10 and 20%, respectively, of its original weight. As noted previously, such meat was considered to have an undesirable dark brown color and was scored lower than were samples held in the laminate of polyethylene and cellophane. Excessive loss of moisture apparently effected changes in color different from the fading due to the action of light and oxygen. The use of a laminated material having low permeabilities to oxygen and to moisture vapor did not prevent fading; this type of discoloration resulted from the reaction of the cured meat

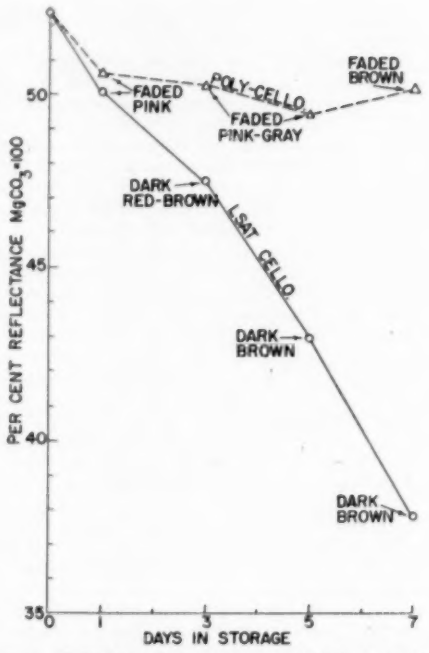


**Figure 3. Relation of packaging materials to changes in color and reflectance of bologna stored under 35-55 footcandles of Soft White fluorescent light. Mean values for reflectance at 540, 570, 600, 650, 700, 750, and 800 mμ.**

pigment with oxygen initially trapped in the package and from the action of oxygen transmitted through the wrapper *(11, 12)*. Fading proceeded from pale pink to gray to pale brown as storage progressed.

In considering the scores noted by the judges, and the moisture losses of bologna packaged with LSAT cellophane (Figures 2 and 4), considerable desiccation (between 10 and 20% weight loss) was required before darkening of the meat became objectionable. With

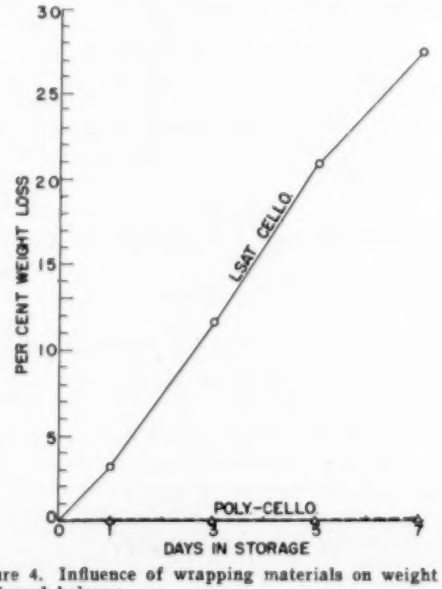


**Figure 4. Influence of wrapping materials on weight losses of packaged bologna.**

regard to darkening, an interesting feature noted was that in the earlier phases of storage, some of the judges preferred the darker color of bologna packaged with the cellophane to the faded pink or grayish pink of meat wrapped with the laminated material.

When sliced bologna was packaged with LSAT cellophane and displayed under Soft White fluorescent light at an intensity of 55 to 65 footcandles, perceptible fading occurred after one hour. Fading was indicated by change in intensity of color from bright pink to pale pink, and by decrease in reflectance. In this trial, samples were checked for discoloration after ½, 1, 2, 3, 5, 6, 7, 9, 21, and 55 hours in storage. In agreement with the findings of Ramsbottom *et al. (9)*, an exposure of approximately 60 footcandle-hours was sufficient to cause fading; the most rapid change in color occurred during the first 4 to 5 hours at the intensity specified.

Vacuum-packaging did not appreciably retard fading of sliced bologna packaged with Saran laminated to cellophane and exposed to 45 to 60 footcandles of Soft White fluorescent light. It should be noted that, in this study, an initial vacuum of about 28.5 in. of Hg was obtained in the packages; this value was less than the initial vacuum of 29.0 in. of Hg specified by Winans *(13)* as requisite for maintenance of color of cured meats. At the end of 6 days the vacuum decreased to approximately 27.0 in. of Hg, a level greater than the minimum of 24.0 in. of Hg cited by Winans *(13)* for stored packages. From measurements of spectral reflectance and from scores given by the judges, the rate of fading was found to be greatest during the first day of exposure to light regardless of whether packages were evacuated or sealed under atmospheric pressure. However, bologna packaged under vacuum did not show as pronounced discoloration as that evidenced by samples wrapped under atmospheric pressure and stored for 1 and 2 days. Although a material considered to be an excellent barrier to oxygen transfer was used in these tests, in accordance with conditions indicated, incomplete evacuation of air did not successfully maintain the original color of sliced bologna. Fading upon exposure to light may be attributed to the action of the small amount of residual oxygen in the package after the evacuation process.

Less fading was produced by light intensities in the range 30 to 35 footcandles than that observed when bologna packaged with LSAT cellophane was exposed to 50 to 60 footcandles of Soft White fluorescent light (Figure 5). As in other trials, fading was fastest during the first day of display. At intervals of 1, 2, 3, and 7 days, bologna held at the lower range of light intensity received higher scores and gave higher values for the reflectance ratio than those noted for meat displayed at 50 to 60 footcandles. The shape of the reflectance ratio curves indicated that the rate of discoloration was lower at 30 to 35 footcandles than it was at the higher level of intensity.

The effect of ultraviolet light compared with that of Soft White fluorescent light in producing color changes in bologna is depicted in Figure 6. When samples were packaged with polyethylene laminated to cellophane and stored under both types of lights, fading was less pronounced and proceeded at a slower rate on exposure to germicidal ultraviolet radiations than was observed after display under Soft White fluorescent light. Of interest in this study was the difference in light intensities provided by the lamps when both were mounted at the same distance from the meat. As measured with the light meter, the ultraviolet lamp produced an intensity of 7 to 10 footcandles at the surface of the samples, while

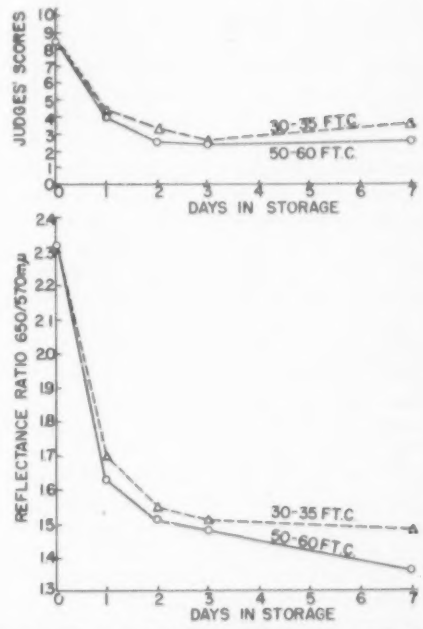


**Figure 5. Effect of light intensity on scores and reflectance ratios of bologna packaged with LSAT cellophane.**

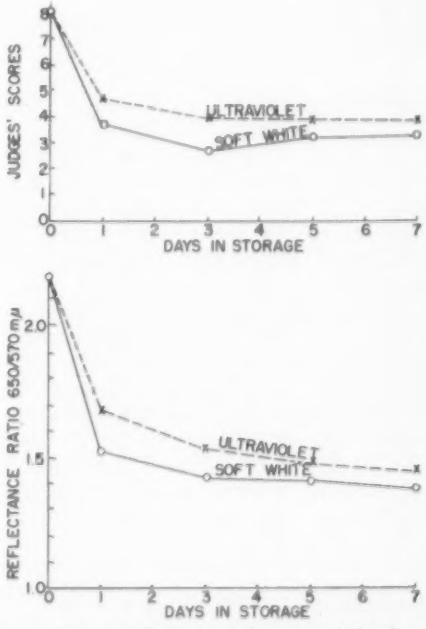


**Figure 6. Effect of display-case lamps on judges' scores and reflectance ratios of bologna packaged with polyethylene laminated to cellophane.**

the Soft White fluorescent light gave an intensity of 35 to 40 footcandles. It was recognized that the glass guard on the light meter may have absorbed part of the ultraviolet light and thereby reduced the intensity incident to the photocell. As indicated previously (Figure 1), the packaging material absorbed a higher percent of radiations in the ultraviolet region of the spectrum than it did in the visible portion; hence the intensity of radiation on the meat surface was less with the ultraviolet lamp than it was when the Soft White fluorescent light served as the illuminant. The greater reduction in light intensity may have accounted for the improvement in color retention by the use of ultraviolet light.

Similar to the results obtained with the polyethylene-cellophane laminate, bologna packed with LSAT cellophane and exposed to ultraviolet light showed less fading than that which resulted from display under Soft White fluorescent light.

Since discoloration due to ultraviolet light was less than that brought about by visible radiation, further evidence may be added to the findings of Taylor and Pracejus *(10)* and Ramsbottom *et al. (9)* that ultraviolet energy caused no greater fading than that produced by the action of visible light.

In all trials, little change in color or reflectance was found with good controls stored in the dark for periods as long as 7 days. Values for the reflectance ratio of these samples ranged from 2.47 to 2.03, corresponding to assigned scores of 10 and 7 respectively. With poor controls, discoloration generally proceeded at a more rapid rate than it did in the case of other samples. During storage for 7 days, reflectance ratios of poor controls varied from 1.53 to 1.36, equivalent to respective scores of 4 and 2. It has been noted that dehydration of bologna resulted in an increase in values for the reflectance ratio; this finding may have contributed a shortcoming to the use of the ratio in establishing scores for poor controls.

## SUMMARY

Changes in color of packaged bologna were determined by a panel of judges and by reflectance measurements. A scoring system based on the ratio of reflectance at 650 mμ to that at 570 mμ was devised for assigning scores to controls. The reflectance ratio served as an objective method for establishing reproducible standards for subjective evaluation of color by the judging panel.

Sliced bologna packaged with a transparent material having high permeabilities to oxygen and water vapor discolored to a greater extent on exposure to light than did similar meat when wrapped with less permeable and less transparent materials. Laminated films which provided good barriers to the transfer of oxygen and moisture vapor did not prevent fading of packaged bologna exposed to light. These materials, however, were sufficiently impermeable to moisture vapor that darkening of the meat did not occur. On the other hand, cellophane permitted appreciable desiccation, resulting in an undesirable dark brown color when weight losses of the meat were greater than 10%. Under these conditions, the reflectance ratio was not as closely related to judges' scores as were values for reflectance at wavelengths from 540 to 800 mμ.

Color fading of packaged bologna was most rapid during the first day of display under Soft White fluorescent light having intensities in the range 30 to 65 footcandles; noticeable fading occurred after an exposure of approximately 60 footcandle-hours.

With an initial vacuum of about 28.5 in. of Hg in the packages, fading of bologna wrapped with Saran laminated to cellophane was not markedly retarded, but was less pronounced than the discoloration observed when air was not excluded from the packages. Retention of vacuum in excess of 27 in. of Hg appeared to be necessary for maintenance of color of packaged bologna during storage.

Fading of bologna was more advanced and occurred faster at light intensities from 50 to 60 footcandles than was noted when the intensity ranged from 30 to 35 footcandles.

Ultraviolet light produced less harmful effects on the color of bologna than those observed when Soft White fluorescent light was used for display of the meat. Improvement in color of bologna exposed to ultraviolet light as compared with color retention when fluorescent light was employed may have resulted from greater absorption by packaging materials of ultraviolet than of visible radiations.

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# Powdered Grape Juice[a]

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(Manuscript received June 30, 1953)

**A process was developed on a pilot-plant scale for the preparation of powdered grape juice. Good flavor is obtained in the product by first recovering the aroma from the juice, then concentrating the juice under vacuum, adding sucrose to the extent of 50% of the grape solids, adding aroma on the basis of the total solids, and drying in a vacuum tray drier under conditions to favor the development of flavor. The product is ground and canned with an inpackaged desiccant to prevent lumping.**

The current trend to fruit juice concentrates has led inevitably to study of the ultimate in such concentrates, i.e., fruit juice powders. The U. S. Department of Agriculture recently announced the successful preparation of powdered orange juice.[c] The present publication describes a powdered grape juice developed at the Bureau of Agricultural and Industrial Chemistry, Eastern Regional Research Laboratory, USDA, in which the flavor is fixed by a method differing from that found satisfactory for orange juice.

## BACKGROUND CONSIDERATION

Mere drying of a fruit juice or juice concentrate to a powder has often been accomplished. If the product is to find public acceptance, however, it must store well and dissolve rapidly, and above all the resulting beverage must possess a good taste and aroma peculiar to the fruit. Attainment of this last attribute poses a problem because in removing the large amount of water necessary to convert a juice to a dry powder, the volatiles, which contribute largely to the characteristic fruit flavor, are ordinarily lost.

Since fruit juices consist largely of water, it would not be economical to convert them to powder by direct drying. A more economical method is to concentrate them in vacuum evaporators, and then to remove the remaining water by vacuum drying to avoid damage by heat. Such a procedure also enables recovery of the volatiles in essence form for later restoration to the product. Methods developed by this Bureau for recovering fruit essences have been published *(1, 2, 3, 4, 7, 8, 9, 10, 12)*. Restoration of essences to juice concentrates entails no difficulties, but since most essences are extremely dilute aqueous solutions of the volatile flavoring components, their addition to dry powder requires special techniques *(11)*.

From Concord grape juice we have produced a powder to which essence need not be restored. The essence is added instead to the concentrate before drying. This is done by recovering the essence from the juice by one of the methods developed by this Bureau, depectinizing the juice, concentrating it under vacuum to approximately 80° Brix, adding sucrose to the extent of about 50% of the grape solids, adding the essence to the concentrate in proportion to the total solids, and then drying the concentrate in a vacuum tray drier, under conditions conducive to the development of flavor. If the sucrose is not used in the procedure just mentioned, the product will be unsatisfactory. It will possess a scorched molasses-like character, and it will lack the characteristic aroma of grape juice. Sucrose not only tends to prevent the development of off-flavors but it aids in the retention of the essence.

The mechanism by which sucrose functions to cause these results is not clearly understood. Sucrose does not participate in the Maillard reaction, and its presence to the extent of 50% of the grape solids would be expected to retard significantly the development of off-flavors, by mere dilution of the reacting ingredients. Its role in retarding off-flavors during drying of the concentrate appears analogous to its ability to prolong greatly the shelf life of grape concentrates at elevated temperature.[d]

In the absence of added sucrose the restored volatiles escape quickly, and hence contribute nothing to the flavor of the product. With sufficient sucrose, the volatiles are apparently retained during drying, at least sufficiently long to react with nonvolatile constituents, thereby enhancing the flavor. This enhancement of the flavor by aging or maturing in the presence of the volatiles has been shown also to take place[d] when grape juice concentrates containing essence were stored for long periods at 35° F. (1.7° C.). When the juice concentrate and essence were stored separately and combined at the time of tasting, the flavor was inferior to that of concentrate stored with its essence.

Although powdered juices represent the ultimate in concentration, they are bulkier than high-density juice concentrates. Therefore, to represent an advance over concentrates, powders must possess some superior attribute. In general this attribute is presumed to be better keeping properties at elevated temperature because of the extremely low water content. The storage properties of the powdered grape juice discussed here are being determined with and without vacuum packing, by tests at room temperature and at 100° F. (37.8° C.). Pending final results of storage, this process is not recommended for commercial use.

## EXPERIMENTAL

**Preparation of the full-flavor concentrate.** The full-flavor grape juice concentrate to be dried was prepared by the method described in *AIC-342 (3)*, except that for better flavor, essence was added in proportion to the total solids rather than in proportion to the grape solids only. Since the concentrate was to be made into a powder, vacuum concentration of the juice was carried even further than the 74.9° Brix recommended in *AIC-342*. Concentrates of 85° Brix or higher may be made without heat damage if rapid evaporation is carried out at high vacuum. A sucrose solution of the same Brix as the concentrate was then added in a quantity corresponding to about 50 parts of sucrose per 100 parts of grape solids. The amount to be added is governed somewhat by the acidity of the juice. Use of much less than this proportion, however, may impair the retention of essence during drying. A fruit acid such as tartaric may be added if required to give a palatable *sugar : acid* ratio. After essence was added in proportion to the total solids present, the concentrate was ready for drying.

**Drying.** The following method of drying full-flavor grape juice concentrate containing sucrose was designed to produce a product with good flavor and a moisture content below about 2% to enable grinding. The operation was carried out in a vacuum shelf drier of conventional design, equipped with platens supplied with water controllable to any desired temperature from tap temperature to 200° F. (93° C.). The vacuum system was capable of reducing the pressure in the empty drying chamber to less than 0.25 inch (6.35 mm.) of mercury.

A typical pilot-plant drying run proceeds as follows: The concentrate is charged to the pan with a loading of 0.9 pound of 80° Brix concentrate per sq. ft. of pan bottom area. Water at 190° F. (88° C.) is circulated through the platens. The pans

[a] Presented before the Thirteenth Annual Meeting of the IFT, Boston, Massachusetts, June 23, 1953.

[b] One of the Laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Service, U. S. Department of Agriculture.

[c] USDA Press Release, "New Orange Powder Developed by USDA Stores Well, Makes Excellent Beverage," issued January 12, 1953.

[d] Unpublished records of Eastern Regional Research Laboratory.

are placed in the drier, the door is closed, the vacuum applied. Before bubbling begins, the concentrate will reach a temperature of 145-155° F. (63-68° C.) When the vacuum reaches 3.5-4.5 inches (89-114 mm.) of mercury absolute, sudden flashing commences, causing a rapid falling of the temperature of the concentrate and vigorous foaming, which rises to a depth of 2 inches or more. This can be considered as the boiling stage preceding drying proper. In about 4 minutes the foaming subsides and the concentrate temperature begins rising from a low of 120-130° F. (49-54° C.). At this point, drying proper may be considered to begin. Experience has shown that the best flavor is obtained by maintaining the concentrate temperature at 160° F. (71° C.) for approximately the last 1½ hours of the drying cycle.

The concentrate temperature was controlled by adjusting the temperature of the platen water. Figure 1 shows the relationship between the temperature of the concentrate and that of the platen water.

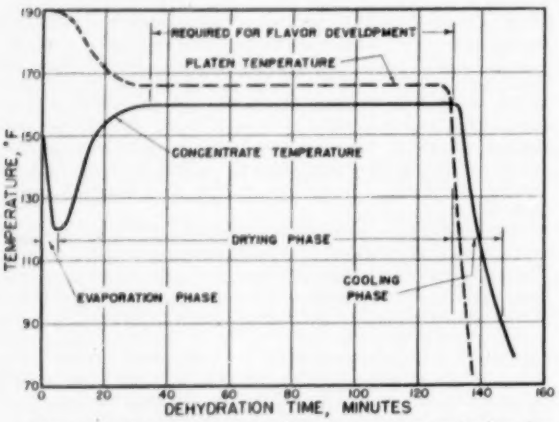


**Figure 1. Concentrate and platen temperatures during drying of grape juice concentrate.**

In order that the dried product will have the desired moisture of between 1.5 and 2.25% and with the time and temperature fixed by flavor considerations as described above, the vacuum during the last 1½ hours must be kept approximately between about 0.35 and 0.45 inch (9-11 mm.) of mercury absolute.

At the completion of drying the product will still show some evidence of bubbling and will be in a molten state. It must, therefore, be cooled before removal from the drier. It is sufficiently brittle at 90° F. (32° C.). The time to cool to a brittle state is dependent on the temperature of the cooling water. Cooling is done under vacuum to prevent rehydration. The total cycle in the drier need not exceed about 2½ hours. This corresponds to a drying capacity of about 0.3 pound of product per hour per sq. ft. of pan bottom.

Some difficulty was encountered in removing the glass-like material from the pans unless precautions had been taken to minimize sticking. The material adhered tenaciously to an uncoated No. 4 stainless steel surface and also to enameled surfaces. Various coating materials were tried on stainless steel, with only moderate success. The best results so far were obtained by coating a stainless steel pan with Johnson's Corrosion Inhibitor Wax.* When a pan so coated was used, the product could be removed by a brisk tap on the bottom of the inverted pan—applied with insufficient force to dent or permanently distort the pan. The product could be easily removed if the pan was first lined with aluminum foil.

**Grinding.** At the completion of drying, the product is glass-like, and after cooling in the drier as described above, can be ground to a granular powder without caking. All operations subsequent to drying, i.e., removal from the pans, further cooling, grinding, and packaging, must be done in a low-humidity room because of the hygroscopicity of the product. The product described above was satisfactorily handled at 70° F. (21° C.) and a relative humidity below 15%. The product was so ground as to have coarse granular structure with no particles retained on a 10-mesh screen (0.065-inch opening) (1.65 mm.). Fine grinding causes gummy lumps when the product is reconstituted.

**Packaging.** To keep the moisture content extremely low, thus preventing caking during storage and prolonging shelf life, the product was hermetically sealed in cans with an envelope containing a desiccant *(5, 6, 11)*. The weight of the desiccant was appoximately one-tenth the weight of the powder. The bulk density of the grape juice powder is about 56 pounds/cubic foot (0.90 g./cc.). A 4-ounce can holds the packaged desiccant and about 3.4 ounces (97 g.) of the powder.

**Reconstitution.** To obtain a beverage of approximately 14.5° Brix, the contents of the can should be dissolved in 4 cans of cold water.

### Storage Properties

One of the incentives for converting a fruit juice concentrate to powder is to obtain superior keeping properties at elevated temperature. Although storage tests are not yet completed on powdered grape juice it is already apparent that its storage properties at 73° F. are excellent. After 6 months at this temperature a trained taste panel could detect only a very slight change in flavor. At the same rate of flavor change the product would be well above the acceptable limit after one year at room temperature.

## CONCLUSION

The reconstituted juice has the characteristic appearance of Concord grape juice. It has a strong grape flavor of pleasing character but somewhat different from that of bottled grape juice.

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* Mention of products in this paper does not imply recommendation or endorsement by the United States Department of Agriculture over other products not mentioned.

# A Practical Control Program for Shipping Containers[a]

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(Manuscript received June 24, 1953)

It is the purpose of this paper to demonstrate how the application of quality control and careful preparation of specifications may effect savings for the users of corrugated shipping containers. The value of a quality control program for this item has not been fully recognized by all users. It is of great importance, since it concerns a vital part of the complete package for almost all food items and a high percentage of other consumer goods.

Design, using as little corrugated board as possible, can probably effect considerable savings; however, the program described here was aimed at obtaining a quality container *through specifications* developed after proper evaluation in the laboratory and field, and at checking these containers *against specifications* by means of a quality control program as they are received by Production.

Upon checking into the packaging history of our containers, we found a large number of shippers with specifications much higher than the minimum requirements for corrugated containers to be shipped by rail as established by Consolidated Freight Classification, Rule No. 41. Unless our problems were greatly different from the rest of the food industry, the indication was that we were overpackaged. However, past experience showed that as the certificate requirements in our containers were reduced we incurred substantial losses due to damage.

This led to the suspicion that our present containers might not be of the strength we specified, but more nearly of the strength required by Rule 41. This became more apparent whenever we lowered our specification requirements.

**Preliminary test program.** To prove this, an exploratory testing program in one of our major locations was initiated to determine the quality and specification compliance of all incoming shipments. We selected the plant which received the largest variety of containers from the greatest number of sources.

The testing program consisted of checking for size, printing, style, flute, and certificate. In addition, bursting (Mullen) tests were made for compliance with Freight Classification, Rule 41. Beyond that, printing impressions on amount of crushing of corrugations under printed areas were recorded. During the four-month duration of this testing program the containers were also checked for defective fabrication such as adhesion, leaning corrugation, squareness of the box, manufacturer's' joints, depth of slots, all of which it is agreed lower the quality of corrugated shippers.

Results over a two-month period showed that 40% of all shippers were defective on at least one or more items. The bursting test received the greatest consideration, since it is a basic requirement of the Freight Classification Committee and is also the main basis on which all shippers are purchased. The bursting test in itself does not determine the strength of a container. However, if the boxboard is of the proper test, if fabrication is good, if corrguating medium is of proper test and well formed, then specific strength requirements can be expected from the container. Approximately 7% of the shipments checked failed to meet the requirements of the printing impression test. This test correlates well with the stacking resistance and cushioning qualities of the shipper. The majority of shipments contained some type of fabrication defect which would lower the strength of the container. All the shipments received met our requirements for size, slotting, and packing.

These results told us that we had been receiving and using lower quality corrugated containers than are required by our specifications. Although we used containers of lower quality, we did not have extensive trouble in actual use. Therefore, we concluded in many cases that a lower strength container will still provide adequate protection. In conjunction with this work, an investigation of damage claims was made in which the higher Mullen test but otherwise lower quality containers were used. From this study it was found that we experienced a very small percentage of damage to our shipments.

It was concluded that if we accepted only quality containers, we would be overpackaged. Therefore, we decided to lower the specification requirements to give the proper level of protection, and as a result realized considerable savings. It should be pointed out that the tests selected for this study do not give all the answers nor are they infallible, but the tests are universal in the corrugated industry and provide the maximum amount of information at the least cost.

**Development of a practical company program.** The results of this preliminary study and testing program proved the need for the development of a practical company program. It is quite possible to develop a program consisting of tests that would provide the majority of answers necessary to determine the absolute strength of each shipment of containers. A program of this type would be extremely expensive and for that reason would be unacceptable, or would have to be limited to very few plants. A program designed to inspect for the greater percentage of inferior shipments is superior and better suited to our particular requirements than a program designed to inspect for all defects within each shipment, resulting in only a small number of the total shipments being checked.

The following program was therefore developed:

a. Equip 8 major locations with the following:
   Bursting (Mullen) Machine
   (with manifold and two gauges)
   Caliper device
   Steel tape measure

b. Initiate routine test procedures to guarantee compliance with specifications.

   In order to perform correctly, at least one skilled employee was needed at each of the designated locations. This was accomplished by each of the selected employees coming to the packaging research laboratory at the same time and being instructed as a class. The type of instruction was not overly complicated or highly technical, but established the proper methods and routines. An employee trained by this method could perform all tests and evaluate one shipment in a period of 15 minutes. With proficiency this time may be reduced. This training program required one week and ended with a visit to a corrugated plant.

c. Reduce specifications to minimum protection requirements. In order to properly determine minimum specifications, careful laboratory tests were performed on each shipping container being considered for reduction. Tests used here were complete and comprehensive—strength tests to check the inherent characteristics of the corrugated board, drop

[a] Presented at the Thirteenth Annual Meeting of the IFT, Boston, Massachusetts, June 24, 1953.

tests to determine resistance to rough handling and accidental falls, compression tests to prove the ability of the box to withstand stacking in shipment and warehousing. We know these tests are necessary because mere compliance with freight regulations does not insure safe arrival of a shipment.

**Development of a manual.** Furthermore, it was found helpful for us to prepare and reproduce a manual (which was supplied to all concerned) containing the procedure to be followed for the inspection of each shipment of containers. This manual is divided into the following categories:

a. Procedure for sampling
b. Procedure for testing
c. Procedure for reporting results

A complete description of the tests employed (as accepted by the Technical Association of Pulp & Paper Industry, American Society of Testing Materials, or other generally accepted procedures) is also included. We supply photographs of all common fabrication defects (Figures 1 through 7 are representative of these) to be used as working standards, the proper terminology of each defect, and a glossary of packaging and corrugation terms in order that intelligent reports on the subject may be written and understood.

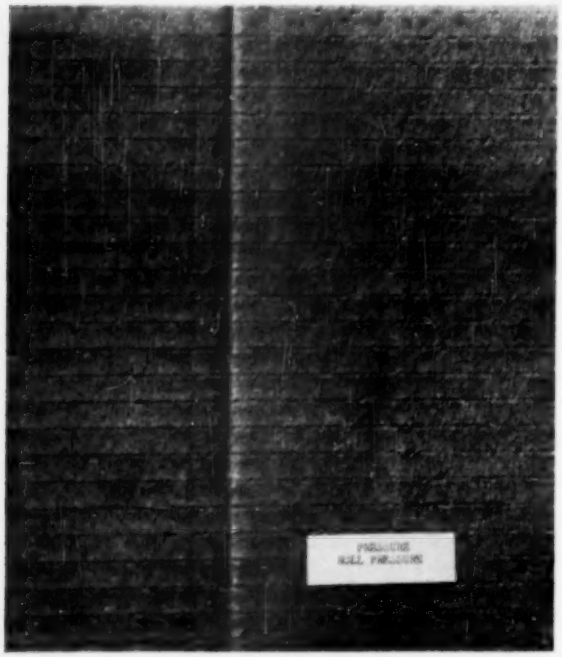

**Figure 1. Preasure Roll Pressure: This defect occurs on the inner facing (inside of box) and is one of the few defects which could lower the bursting (Mullen) strength.**

To be more specific, testing procedures are based on 2 methods, the mechanical tests and the visual inspections. The mechanical tests involved are the bursting (Mullen) test and the printing impression test. The bursting (Mullen) test checks the compliance of the board with Freight Classification Requirements and gives some indication of fabrication defects as well.

The printing impression test determines the degree of crushing of the corrugations as a result of the printing operation. This test gives an indication of the possible effects of printing on the stacking resistance and cushioning abilities. Consideration is given to the fact that a normal printing procedure requires a certain amount of pressure in order to obtain good coverage on the variations of board thickness. We know that beyond a certain point the strength of the container can be

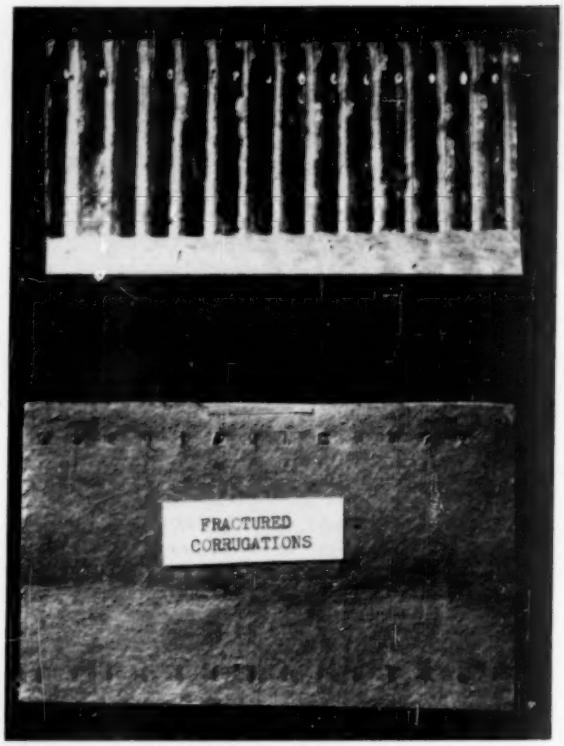


**Figure 2. Fractured Corrugations: A straight line of cracks or cuts at the heads of the corrugations parallel to the fingers; this defect can lower compressive resistance (stacking strength).**

impaired. Therefore, we established standards (varying with the size of the flute) for rejecting containers. The visual checks are made to determine correct size, style, certificate, corrugations, slotting, bundling, count per bundles, and fabrication defects. The inspection for fabrication defects is probably the most important single test as the majority of inferior containers are not the result of poor materials, but the result of inadequate fabrication.

The success of any testing program is based on the accuracy of the results. In order to maintain this accuracy, correlating procedures were devised, collaborative samples are sent to each of our testing locations and a certain number of tests conducted. These samples are then returned to our research laboratory and checked against our master machine. If the examination of results shows that the allowable error is exceeded by a particular location, it is immediately notified and corrective measures taken.

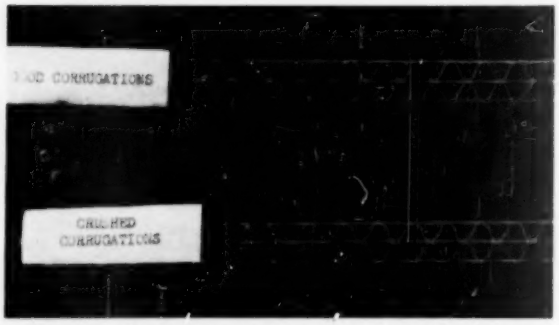


**Figure 3. Crushed Corrugations: The side walls of the corrugations are broken and distorted; lower compressive strength (stacking resistance) can result.**

The preceding method is used principally as a double check on the over-all accuracy of the operator and his equipment. In addition, separate tests are conducted by the technician to check the working parts of the bursting (Mullen) machine that fre-

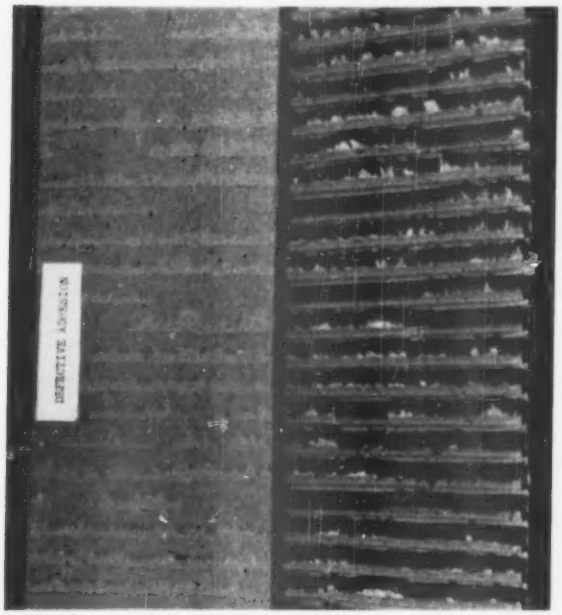


Figure 4. Defective Adhesion: Intermittent areas of poor bonding or lack of adhesive; both compressive (stacking) strength and bursting (Mullen) strength are decreased.

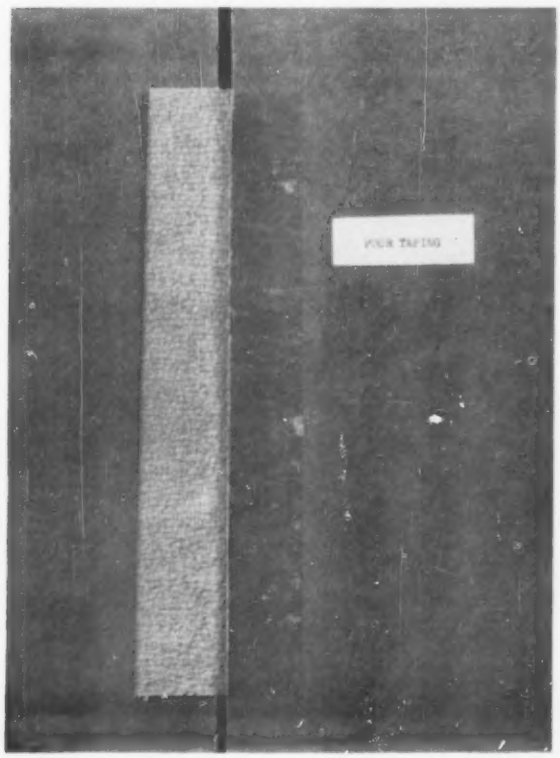


Figure 5. Poor Taping: Poor bonding of the tape to the box, or possibly the tape is too short or too long; loss of contents or production difficulties can result.

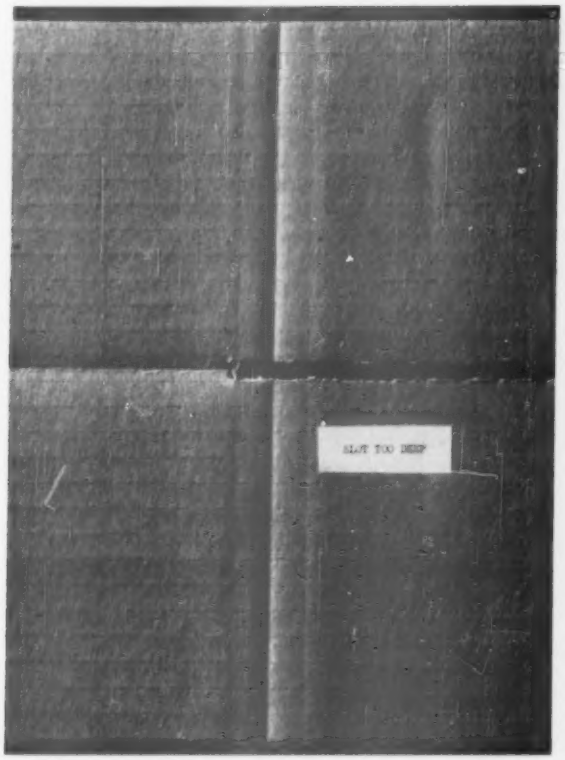


Figure 6. Slots Too Deep: Slots entering too deep into the body panels can lower compressive resistance (stacking strength) and allow entry of foreign materials.

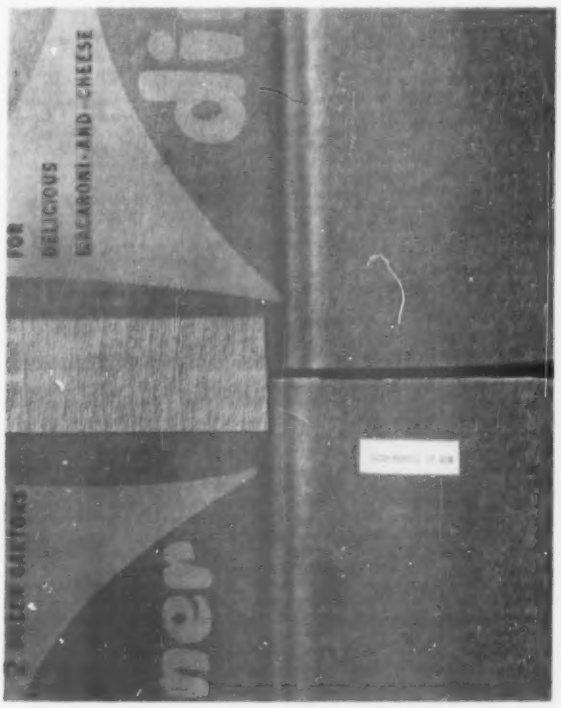


Figure 7. Squareness of Box: The ends of the blank at the manufacturer's joint do not line up at scores of flaps, causing improper closing of the flaps and throwing entire box out of square.

quently produce errors. The first of these is a daily check on the diaphram in order to determine if the elasticity of the rubber has been impaired by previous use. A new diaphram is also checked by this method for acceptability. Another of these tests is the checking of gauges which is done periodically at the research laboratory by means of a dead weight tester. When errors are found in the gauges, they are returned to the manufacturer for the proper repair and replacement gauges issued. Several additional checks that are made after considerable usage or as needed include: clamping-plate parallelism, lubrication of gear box, eliminating of air in system (after changing either gauges or diaphrams), and changing of glycerine in system.

It has been found that the accuracy is reflected by the technician's ability to provide his own maintenance and to achieve a better understanding of the testing device.

### THE BENEFITS

We have previously discussed the basic necessity of our control program, its development, and the final program as it is now being followed. Let us now consider the benefits that can be realized through the use of such a program. At the beginning of this report it was stated that the program was basically designed to assure ourselves of accepting materials that meet our requirements as specified. Therefore, we are now receiving exactly what we are paying for. With this established, plus the fact that we found the lower strength containers still provided adequate protection, we reduced the strength to that level on a number of our containers. This, of course, provided a considerable saving of money. The results obtained on a great number of shipments from individual suppliers enables the Purchasing Department to buy more critically and the Production Department to operate more securely.

In addition, the results compiled over periods of time provide invaluable information for further research studies and more adequate specifications.

By using their own facilities, users of corrugated shipping containers may determine for themselves the value of this program. If facilities are not available, services of an outside consulting laboratory may be secured.

The details of the specifications we have discussed here may not apply to all and were, therefore, not included in this paper. The details of the tests used were not described since they are covered in the literature on the subject of testing corrugated materials.

This program of inspecting materials carefully at the point they are received was accepted by all of our suppliers, who have cooperated with us to arrive at mutually satisfactory standards and methods of testing.

# Ionizing Radiations for the Control of Fish Spoilage[a]

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(Manuscript received June 30, 1953)

**A study was made of the effect of cathode rays on control of fish spoilage caused by bacteria. Haddock fillets were irradiated with supervoltage cathode rays and then stored at 36°-40° F. The dose levels used were 4 x $10^5$, 5 x $10^5$, and 6 x $10^5$ rep at 2 m.e.v. and 6 x $10^5$ and 7 x $10^5$ rep at 3 m.e.v. Standard plate counts, trimethylamine nitrogen analyses, and organoleptic examinations were made on the irradiated and control samples at the start and after 2 to 6 weeks of storage at refrigerator temperatures above freezing.**

In 1943, studies were initiated by one of the authors *(8)* to determine whether highly contaminated ground meat could be sterilized with high-energy X-rays. The successful conclusion of this experiment, together with the availability of particle accelerators, led to the use of cathode rays for the purpose of destroying microorganisms, because there is much greater efficiency of utilization of the energy applied with cathode rays than with X-rays. In 1945, a research program was established at the Food Technology Laboratories, Massachusetts Institute of Technology, to determine the feasibility of using ionizing energy in the form of cathode rays to sterilize foods, drugs, pharmaceuticals, and biologicals.

[a] Presented at the Thirteenth Annual Meeting of the IFT, Boston, Mass., June 23, 1953. Contribution No. 165 from the Dept. Food Tech., Mass. Inst. Tech., Cambridge, Mass.

In 1950, Nickerson, Goldblith, and Proctor *(4)* used high-voltage cathode rays to sterilize mackerel. In the same year they *(7)* used this method for sterilizing haddock fillets. These researches dealt with chemical changes in fish tissues caused by the action of bacteria and by autolysis and were not concerned with the destruction of microorganisms for the purpose of increasing the storage life of fish products held at temperatures above freezing.

According to our studies *(6)*, ionizing radiations at high levels may be used to destroy microorganisms of all kinds that may be present in a food product, but such severe treatment may induce undesirable flavor changes. For example, it has been found that fish fillets, after treatment with sterilizing doses of cathode rays, have typical, irradiated, off-flavors. It has been shown by Nickerson and co-workers *(5)* that in general, the greater the dose of cathode rays applied, the greater the extent of flavor change induced in food products.

Dunn *et al. (2)* and Brasch *et al. (1)* demonstrated that vegetative bacteria were destroyed by much lower doses of ionizing radiations than was the case with spore-forming bacteria.

With these facts in mind, it was considered worth while to irradiate fish fillets at doses that would not destroy all organisms but would destroy the majority of psychrophilic organisms. The object of such a treat-

ment was to extend the storage life at refrigerator temperatures above freezing, without inducing off-flavors as a result of the irradiation treatment.

## EXPERIMENTAL METHODS

**Sample preparation and irradiation.** Fresh haddock fillets were washed under a stream of cold running water and then placed on absorbent paper to permit drainage of excess moisture. Fillets for organoleptic examination were cut into sections measuring approximately 3 x 5 inches and heat-sealed in individual cellophane bags (300 MSAT). Twenty-gram-unit samples for bacterial and trimethylamine nitrogen analyses were obtained from the thickest portion of several fillets and were packaged individually in small cellophane packets and sealed. Non-irradiated control samples were stored in a freezer at —40° F. (—40° C.) and some also in a refrigerator at 36°-40° F. (2.2°-4.4° C.). Irradiated samples were held at 36°-40° F.

The source of the cathode rays was a Van de Graaff accelerator *(9)* with a 3 m.e.v. capacity. Samples were placed on a motor-driven belt, whose path the electron beam traversed, and were irradiated first on one side, then the other. Fish samples of one experimental run were subjected to a dose of 4 x $10^5$, 5 x $10^5$, or 6 x $10^5$ rep. at 2 m.e.v. and also at 3 m.e.v. A periodic examination over a 2-week storage period ensued. Another group of samples received doses of 6 x $10^5$ and 7 x $10^5$ rep, respectively, at 3 m.e.v. only and were held in storage for 6 weeks.

**Bacterial analysis.** Standard bacterial plate counts were made on irradiated and non-irradiated samples immediately after treatment and at intervals during subsequent storage. Twenty grams of fish were blended in a sterile Osterizer for 5 minutes with 180 ml. of chilled, sterile, distilled water. Appropriate dilutions were plated on tryptone glucose extract agar, and samples were incubated at 68° F. (20° C.) for 4 days before counts were made.

**Trimethylamine nitrogen analysis.** Irradiated and non-irradiated fish were examined for their trimethylamine nitrogen content immediately following irradiation and at periodic intervals during storage. Trimethylamine nitrogen was determined by the method of Dyer *(3)*, which consists essentially of a toluene extraction of the alkaline sample and a colorimetric measurement of the picrate salt.

**Organoleptic examination.** A triangle taste test was conducted at 2-week intervals on the fillets that had been irradiated at doses of 6 x $10^5$ and 7 x $10^5$ rep and on frozen controls. A 20-member panel was used. All samples were pan-fried for approximately 15 to 20 minutes to a golden brown color and served warm. Hydrogenated fat was used for cooking purposes. Judges were asked to differentiate the pair from the odd sample and also to state the acceptability of each.

## RESULTS AND DISCUSSION

Figure 1 clearly illustrates the efficacy of ionizing radiations in reducing the initial bacterial load in haddock fillets. The superiority of the 3 m.e.v. over the 2 m.e.v. energy in reducing the bacterial load during the 2-week storage period is also apparent. This is ascribable to the fact that cathode rays at 3 m.e.v. have greater penetration into fish flesh than rays at 2 m.e.v. At the higher irradiation doses, the bacterial population of the irradiated samples after 2 weeks of storage at 36°-40° F. (2.2°-4.4° C.) still remained at a relatively low level, whereas that of the non-irradiated control under the same storage conditions had increased to approximately 7 x $10^8$ organisms per gram.

The results of simultaneous trimethylamine nitrogen determinations on this same lot of fish are presented in Table 1. Here again the influence of supervoltage cathode rays in inhibiting bacterial production of tri-

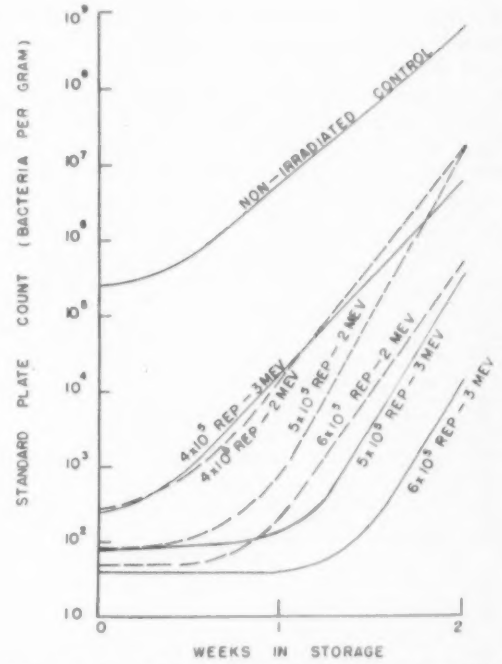


**Figure 1. Bacterial count of haddock fillets irradiated at various doses and voltage levels as compared with controls held at 36°-40° F.**

methylamine nitrogen in stored haddock is remarkably demonstrated. According to the standards of this test, the non-irradiated samples were definitely spoiled after 2 weeks of storage, whereas the irradiated samples still had an appreciably low trimethylamine nitrogen content at this time.

These preliminary results indicated that a treatment dose of at least 6 x $10^5$ rep at 3 m.e.v. or in excess would be required to maintain a low bacterial count in haddock fillets held in prolonged storage at 36°-40° F. In view

**TABLE 1**

**Trimethylamine nitrogen content of haddock fillets irradiated at various dose and voltage levels as compared with non-irradiated samples**

| Irradiation dose | Trimethylamine nitrogen content [b] | | | |
|---|---|---|---|---|
| | Initial | | 2 weeks at 36°-40° F. | |
| | 2 m.e.v. | 3 m.e.v. | 2 m.e.v. | 3 m.e.v. |
| | *mg. %* | *mg. %* | *mg. %* | *mg. %* |
| 4 x $10^5$ rep | 0.09 | 0.09 | 1.13 | 1.03 |
| 5 x $10^5$ rep | 0.18 | 0.15 | 1.33 | 2.52 |
| 6 x $10^5$ rep | 0.12 | 0.06 | 2.13 | 2.04 |
| Non-irradiated control | 0.13 | | 61.5 | |

[b] Average of two determinations.

of these preliminary findings, a long-range program was initiated whereby haddock fillets irradiated at 6 x $10^5$ rep and 7 x $10^5$ rep were maintained at 36°-40° F. and examined periodically until they became unacceptable from the standpoint either of bacterial population or of flavor. Figure 2 illustrates the general trend of the bacterial plate counts made on the irradiated samples held up to 6 weeks at 36°-40° F. and the trend of the counts made on the frozen control held at —40° F.

(—40° C.). After 19 days of storage the bacterial population of the sample treated with 6 x $10^5$ rep had risen to the same count as that of the frozen control. This level was not attained by the sample irradiated at 7 x $10^5$ rep until the twenty-eighth day of storage.

If a graphical interpolation of the data given in Table 2 were made, it would show that after 22 days the fish

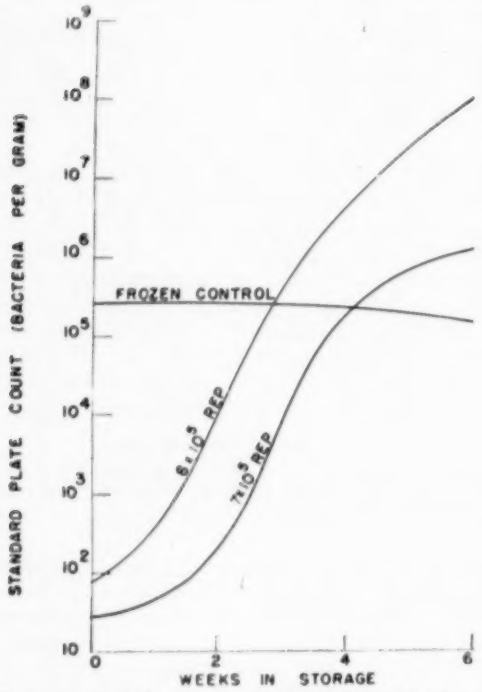


**Figure 2. Bacterial count of haddock fillets irradiated at various dose levels and held at 36°-40° F.**

treated at 6 x $10^5$ rep had attained a trimethylamine nitrogen content of 10 mg.%, whereas the fish treated at 7 x $10^5$ rep had attained a content at an insignificantly low level after 6 weeks.

An organoleptic examination (Table 3) revealed that a significant difference existed between the flavor of non-irradiated fish and fish irradiated at 6 x $10^5$ and 7 x $10^5$ rep. A statistical analysis of the acceptability data, based on the partial sums of binomial probability distributions related to specific taste panel sizes, showed that the irradiated samples were still acceptable at a 95% level of significance.

**TABLE 2**

**Trimethylamine nitrogen content of irradiated and non-irradiated haddock fillets held at 36°-40° F.**

| Irradiation dose at 3 m.e.v. | Trimethylamine nitrogen content [a] | | | |
|---|---|---|---|---|
| | Initial | 2-week storage | 4-week storage | 6-week storage |
| | *mg. %* | *mg. %* | *mg. %* | *mg. %* |
| 6 x $10^5$ rep | 0.92 | 1.08 | 21.80 | 24.66 |
| 7 x $10^5$ rep | 0.87 | 1.27 | 1.57 | 0.23 |
| Non-irradiated frozen control | 0.79 | 0.52 | 0.69 | 1.00 |

[a] Average of four determinations.

**TABLE 3**

**Organoleptic evaluation of irradiated haddock fillets stored at 36°-40° F. as compared with frozen controls**

| Dose at 3 m.e.v. | Storage period | Triangle test evaluation | | | Percent of correct judges who rated irradiated samples | |
|---|---|---|---|---|---|---|
| | | Number correct judges | Number incorrect judges | Significance | Acceptable | Non-acceptable |
| *rep* | *weeks* | | | *%* | | |
| 6 x $10^5$ | 2 | 12 | 8 | 5.0 | 75 | 25 |
| 7 x $10^5$ | 2 | 13 | 7 | 1.0 | 31 | 69 |
| 6 x $10^5$ | 4 | 15 | 5 | 0.1 | 53 | 47 |
| 7 x $10^5$ | 4 | 14 | 6 | 0.1 | 64 | 36 |
| 6 x $10^5$ | 6 | 15 | 5 | 0.1 | 67 | 33 |
| 7 x $10^5$ | 6 | 13 | 7 | 1.0 | 61 | 39 |

## SUMMARY

It has been shown that high-voltage cathode rays may be used to destroy bacteria on haddock fillets, thereby extending the storage life of such products when held at refrigerator temperatures above freezing. Much lower doses of ionizing radiations were used for this purpose than would be required to destroy all microorganisms that might be present on fish fillets.

From the standpoint of destruction of bacteria and the extension of storage life at temperatures of 36°-40° F. (2.2°-4.4° C.), energies of 3 m.e.v. gave better results than energies of 2 m.e.v. at the same dose level. This indicates that some penetration into the flesh of the fish fillet is necessary to bring about an effective destruction of microorganisms.

Statistical analysis of the results of organoleptic tests made on irradiated samples held as long as 6 weeks at 36°-40° F. and on controls preserved by freezing indicated that the irradiated samples might be considered acceptable.

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# A Comparison of Objective Tests for Quality of Gulf Shrimp[a]

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(Manuscript received June 5, 1953)

**Freshly caught Gulf shrimp stored in crushed ice were sampled daily for chemical, bacteriological and organoleptic tests. The correlation of the results of the chemical and bacteriological data to quality and spoilage is discussed.**

Changes in seafoods during storage have been the subject of many investigations. Despite the time and effort expended, however, no completely satisfactory test has been devised for evaluating the quality of the products, nor is there agreement among workers as to the main cause or type of change occurring.

The general opinion is that spoilage results from the liberation of compounds through the action of microorganisms, the resulting compounds imparting off odors and flavors. It is recognized that enzymes in fish tissue may also be responsible for liberation of compounds associated with loss of quality. Enzymatic changes are usually considered of less importance than those induced by microorganisms.

If some compound originally present in fish tissue should gradually decrease in amount through the action of bacterial or tissue enzymes, it should then be possible, theoretically at least, to arrive at a numerical quality index. From such data it would be possible to state the length of time the product had been stored, its probable future storage life, and its quality at any given instant. Similarly, the formation of a compound might be used as a measure of quality or of future storage life. Unfortunately, up to the present no such simple relationships have been shown to exist.

When fresh shrimp are to be stored, it is the usual practice to place the shrimp in alternate layers in crushed ice. Storage on the shrimp trawlers may vary from one day to as long as 21 days, although usually shrimp are not held longer than 14 days. Further storage may result if the fresh shrimp are transported to distant markets. The shrimp industry in general and the shrimp fishermen, shrimp handlers, and processors of frozen shrimp in particular, would be especially interested in a rapid objective test for evaluating quality. The industry is at present using visual observation and odor as criteria of quality. The present investigation was undertaken (a) to determine whether a single test or a combination of tests could be used objectively to measure quality of freshly stored shrimp, and (b) to determine whether any of the tests could be used to estimate both length of time the shrimp had been in ice storage prior to sampling and their probable future storage life.

To determine the effect of ice storage upon the quality of shrimp, freshly caught shrimp were packed in ice and transported to the laboratory. Upon arrival at the laboratory the shrimp were washed in cold water and all the cut and crushed shrimp removed. The remaining headless shrimp were packed in a single layer in ice in a wooden box (24 x 28 x 36 inches) and stored in a refrigerated room at 38° F. (3.3° C.). The layer of ice beneath the shrimp was sufficiently thick so that it was unnecessary to repack the shrimp during the course of the experiments. At the temperature of the storage room sufficient ice melted to prevent the serious development of black spot *(6)* and to maintain the shrimp at 32° F. (0° C.). Daily samples were removed for chemical, bacteriological and organoleptic tests; the shrimp were not washed or peeled after taking the samples. The chemical determinations included the following: tyrosine reaction *(14)*, amino nitrogen *(9)*, trimethylamine nitrogen *(5)*, and volatile acids *(7)*. The bacteriological examination consisted of determining total plate counts *(8)*. For the organoleptic test, daily samples were placed in one-piece telescope cartons,[b] overwrapped with glassine, frozen and stored at —40° F. (—40° C.). At the termination of the experiment the shrimp were thawed, cooked in tap water, for a total boiling time of eight minutes, and panel tasted by 4 experienced judges.

## EXPERIMENTAL RESULTS

Five separate experiments in which freshly caught shrimp were stored in ice were undertaken. Although the 5 lots of shrimp were caught in different locations, were of different size count, and in one case were *Peneaus aztecus* while the other 4 were *Peneaus setiferus*, the analytical data were consistent. Data will be presented, therefore, for only the former species. Two advantages in using these data are that samples of 0 days, 6 days, and 12 days ice storage were frozen and are being analyzed monthly, and that accurate information of their history is on record. These shrimp were caught in the Gulf of Mexico 12 to 16 miles south of the west end of Grand Isle, Louisiana, in 12 to 16 fathoms of water. They were a composite taken from 2 drags caught at 2:30 a.m. and 5:30 a.m. Within one hour after catching, the shrimp had been headed, thoroughly washed with sea water, and packed in crushed ice. The shrimp arrived at the laboratory at 6:00 p.m. at which time they were washed in cold water and the experiment was undertaken.

Of the chemical tests used, the values for the tyrosine reaction did not show any definite trend although the daily values fluctuated quite widely and irregularly. It was concluded that this test was of no value as an indicator of quality or length of storage of fresh headless Gulf shrimp.

The values for both trimethylamine nitrogen and volatile acids are of limited usefulness as a measure of quality or length of storage of shrimp. During the first 9 to 14 days in the case of trimethylamine determinations and 11 to 17 days for analysis of volatile acids, both gave values which remained relatively constant. After this initial period both gave values which increased significantly, and lagged 2 or 3 days behind a similar increase in total bacterial plate count. The rise in trimethylamine values corresponded to a plate count of 25,000,000. The relationship between these values is shown in Figures 1 and 2.

The chemical test which appeared to have greatest merit as a measure of quality of ice stored shrimp was the determination

[a] Presented before the Thirteenth Annual Meeting of the IFT, Boston, Massachusetts, June 23, 1953.

[b] Manufactured by the Marathon Corporation.

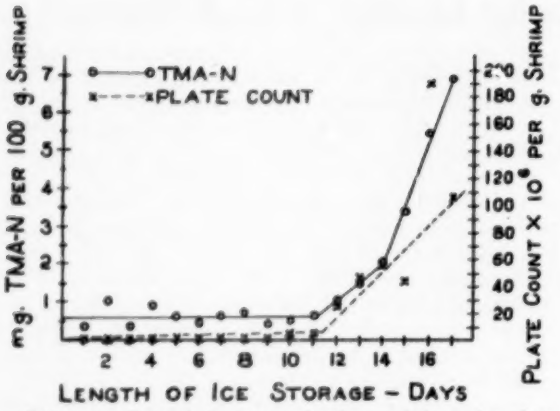


Figure 1. Trimethylamine production and bacterial plate counts of fresh shrimp stored in ice.

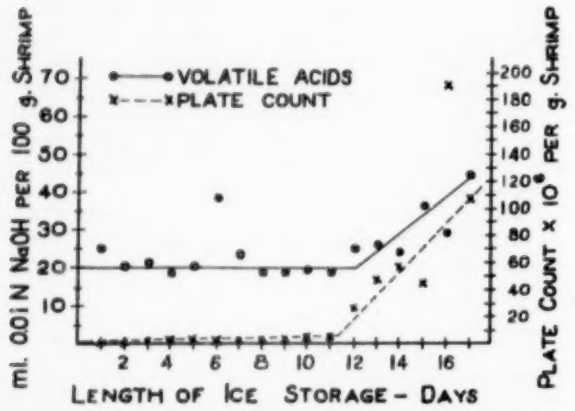


Figure 2. Volatile acids production and bacterial plate counts of fresh shrimp stored in ice.

of amino nitrogen. These values decreased in magnitude as the length of storage time increased, Figure 3. It is to be noted, however, that rather wide fluctuations occurred in the values obtained, particularly during the early period of storage. The decrease in the values for amino nitrogen reported here agree with similar changes reported by Beatty and Collins *(1)* in their studies on press juice from cod tissue. They are opposite, however, to that reported by Campbell and Williams *(3)* for shrimp and Sigurdsson *(11)* for herring, both obtaining increases in amino nitrogen during refrigerated storage. Beatty and Collins *(1)* found the decrease in amino nitrogen approximately equals the increase in ammonia nitrogen and they suggest that bacterial deamination of amino acids liberated from tissue proteins would account for the results they obtained. It should be pointed out that in 5 separate experiments of ice storage of freshly caught shrimp, in all cases the amino nitrogen values decreased with increased storage time. Further studies are being undertaken to evaluate more thoroughly its usefulness as an index of quality of shrimp.

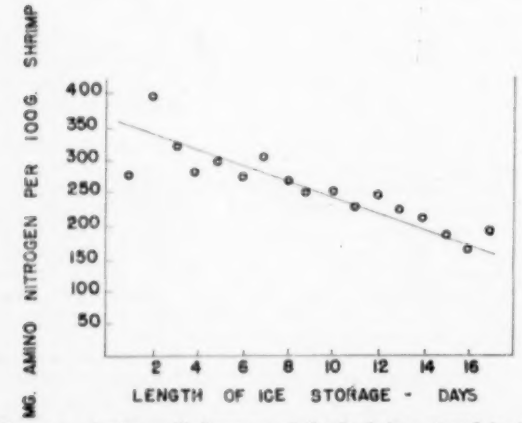


Figure 3. Amino acid decrease of fresh shrimp stored in ice.

The results of taste panel experiments showed that the palatability and flavor of the shrimp decreased slightly during the first 5 days of storage, Figure 4. Following this initial

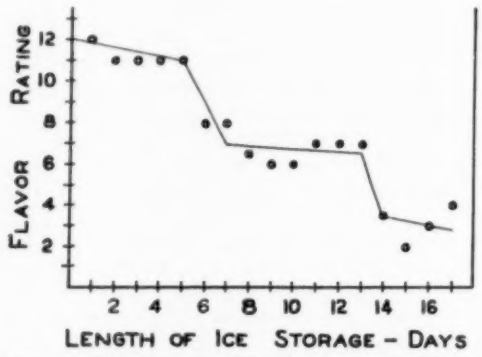


Figure 4. Flavor changes of fresh shrimp stored in ice.

period a sharp break in the curve is evident, and by the 8th day the shrimp had lost their characteristic sweet shrimp flavor. They now were characterized, for approximately 7 days, by having a flat taste or were tasteless. During this period no off flavors associated with spoilage were noted. The cooked meats did not have the opaque white appearance of cooked fresh shrimp, but rather a faint bluish translucent appearance, which one would associate with insufficiently cooked shrimp. This second period was followed by another sharp break in the flavor curve. At this time off flavors were evident and in our opinion these shrimp were inedible.

## RESULTS AND DISCUSSION

For evaluating early stages of storage of shrimp, the measurement of trimethylamine nitrogen or volatile acids is of limited value. Only after spoilage has occurred, as shown by organoleptic tests or visual observation, are these tests of value. It is contended that in control work, there is little value in any test which is valid only after definite organoleptic evidence of spoilage. Dyer and Dyer *(4)* consider a level of 15 mg. of trimethylamine nitrogen per 100 g. of cod fillet tissue the borderline between acceptance and rejection. Stander, Grewe, Marks, and Rowan *(12)* state that for stock fish stored in air at 32° F. (0° C.) the first suggested odor change occurred in the range of 6-15 mg., trimethylamine nitrogen per 100 g. of fish. Above 15 mg. the fish were definitely spoiled. When fish were stored in ice, considerable leaching of trimethylamine occurred, and after 9 days, when the fish had an off odor the trimethylamine values ranged between 2 and 10 mg. With shrimp stored as indicated above, off odors and spoilage were evident when the trimethylamine content reached 1.5 mg. nitrogen per 100 g. of shrimp. With respect to volatile acids the break in the curve occurred 1 to 2 days later than for trimethylamine. With unspoiled shrimp neither of these tests are of value in denoting how long

the shrimp have been stored, their future probable storage life, or their quality at the time of sampling.

As indicated above, amino nitrogen values appear to have considerable merit. The following tentative values are suggested as indicators of probable length of storage: greater than 275 mg. amino nitrogen per 100 g. shrimp, 0 to 8 days; 275 to 200 mg., 8 to 14 days; 200 to 150 mg, 14 to 17 days and less than 150 mg. longer than 17 days. The above values apply to shrimp of 28 count per pound. For shrimp of smaller sizes, values for amino nitrogen were somewhat lower so that the suggested values will have to be used with reservation. Further investigations are being undertaken to determine the amino nitrogen values during storage of different sizes of shrimp.

From his studies of iced white fish Shewan *(10)* divided the course of spoilage into 4 phases. During the 1st phase of 0 to 6 days there was no marked spoilage. In the 2nd phase of 6 to 12 days the first definite signs of spoilage became evident. These consisted of softer flesh, staler appearance and strengthening of the odor. From 12 to 16 days these become more intense and are designated the 3rd phase. In the 4th phase of 16 days and over, rapid deterioration from staleness to putridity occurred. For ice stored shrimp it is suggested that the progressive changes in quality be divided into 3 phases or stages. During the 1st period of 0 to 7 days of storage the shrimp gradually lose their characteristic sweet flavor. The flesh of the cooked product is firm and has an opaque white color. The 2nd stage from the 8th to the 14th day of storage is characterized by a tasteless product, the cooked meat is softer and the color changes to a very faintly bluish opalescent appearance. Cooking these shrimp for 30 minutes in boiling water does not change their appearance to the opaque white of fresh shrimp of phase 1. In phase 3, over 14 days storage, rapid deterioration occurs. The shrimp are softer and off odors of amines become pronounced. At the present time the shrimp industry is attempting to improve the quality of shrimp products placed on the market. The results reported here indicate that prime quality fresh shrimp, which have the characteristic sweet flavor of the freshly caught product, can result only when the shrimp are ice stored for periods shorter than 7 days. If stored for 8 to 14 days the consumer will obtain a poorer product in flavor, appearance and texture. These recommendations for storage time are more stringent than those recently suggested by Campbell and Williams *(3)*.

On the basis of the evidence presented 2 types of changes are postulated to account for loss of quality and spoilage of shrimp. One of these causes loss of the sweet flavor and some softening of the tissue. These changes predominate during the first 7 days of ice storage and probably are catalyzed by tissue enzymes and can be designated as tissue autolysis. While loss of quality progresses during this period, spoilage has not occurred. This indicates there is no ripening process such as occurs with meat. The other type of change predominates during the later storage period and results from the multiplication of bacteria. Some of the products of bacterial action give to the shrimp the odors and flavors associated with spoilage. From their studies of changes occurring in cod and haddock during storage the Canadian workers *(2, 1, 13)* have proposed a similar scheme to account for loss of quality and spoilage.

## SUMMARY

Chemical, bacteriological and organoleptic studies were made daily on samples taken from ice-stored fresh headless shrimp.

Of the 4 chemical tests used to determine quality the tyrosine reaction was shown to be of little or no value. Determinations of trimethylamine nitrogen and volatile acids were of value in indicating whether spoilage had occurred, but did not give information of pre-spoilage changes. Significant increases in bacterial plate counts preceded by 2 or 3 days similar increases in volatile acids and trimethylamine nitrogen values. Amino nitrogen values decreased with increasing storage time and correlated quite well with taste panel tests of flavor and quality.

The results of taste panel testing is of particular value to the shrimp industry. In our studies, during the first 7 days of ice storage the shrimp gradually lost their characteristic sweet flavor. This was followed by a period of 7 days during which they were tasteless. Beyond 14 days' storage spoilage occurred with the development of off flavors.

It is postulated that loss of quality during the early period of storage is mainly caused by autolysis and with longer storage spoilage occurs mainly through bacterial action.

### Acknowledgments

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# Microbiological Aspects of Orangegg[a]

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**In a study of the microbiology of orange egg it is shown that this nutritious beverage is an unfavorable medium for the growth of S. typhimurium and M. pyogenes var aureus. Low pH and the presence of citric acid inhibit the growth of these micro-organisms.**

Orangegg, which has grown in popularity with the increased use of frozen orange juices, consists of about 20% whole egg and 80% orange juice (one egg in 8 oz. of juice) according to Niles *(10)*, Rombauer and Becker *(12)*, Poultry and Egg National Board *(11)* and others. Orangegg is nutritious and an easy means of supplying added nourishment for children, convalescents and normal adults. Either yolk or whole egg may be used.

Since raw egg white contains avidin which interferes with the utilization of biotin, the desirability of eating raw eggs has been questioned. But since there is ample biotin in the yolk and other food in the normal diet to combine with the avidin of the white, an ample quantity is available to meet nutritive requirements *(5)*.

Because eggs may contain salmonellae and because they provide a good medium for the growth of other bacteria the danger of food poisoning from the use of orangegg requires investigation. Few shell eggs contain salmonellae, and the number present is small according to Cantor and McFarlane *(2)* and others. Unless they multiply appreciably in orangegg, there would probably be little or no danger in use of the drink made with eggs which might contain salmonellae. This is especially true in the case of normal adults. McCullough and Eisele *(8)* reported that it required a large intake of *Salmonella* bacteria to produce food poisoning in this type of individual. However, this might not hold true in the case of children and convalescents. More information is needed.

Orange juice, because of its low pH, citric acid content and other factors is not a favorable medium for the growth of pathogenic bacteria, especially staphylococci and salmonellae, as indicated by the work of Hahn and Appleman *(7)* and Wethington and Fabian *(14)*. The modification of the bactericidal properties of orange juice by the addition of egg is unknown.

The objectives of this study have been to determine the growth of *Salmonella typhimurium* and *Micrococcus pyogenes* var. *aureus* in orangegg, containing different concentrations of egg, and held at room and refrigerator temperature for 24 to 48 hours.

[a] This study was supported in part by a grant-in-aid from the Poultry and Egg National Board.

## PROCEDURE

Orangegg was prepared by adding one or 2 whole eggs to each 8 oz. of fresh or reconstituted frozen orange juice and mixing in a Waring blender. Each batch of orangegg was divided into 2 lots. One was held as the uninoculated control. The other was inoculated with one or more 24-hour broth cultures of pathogenic strains of *Micrococcus pyogenes* var. *aureus (Staphylococcus)*, and/or salmonellae. In the early trials half of the inoculated and uninoculated samples were held in a refrigerator at 45° F. (7.2° C.) and the remainder in a kitchen at 80° F. (26.7° C.) for 48 hours. In the later trials, the samples were held only in the kitchen.

The samples were analyzed for bacterial counts according to the methods of the Association of Official Agricultural Chemists *(1)*. Standard plate counts were made on Bacto tryptone glucose extract agar. Staphylococci were counted on phenal red mannitol agar containing 7.5% sodium chloride according to the method of Chapman *(3)*. *Salmonellae* were counted on Bacto SS agar. Only colonies that were black or had black centers were counted as salmonellae. The samples were analyzed as soon as prepared and after holding 24 and 48 hours.

## RESULTS AND DISCUSSION

**Total bacteria.** Eleven samples of inoculated and control orangegg were analyzed for standard plate bacterial count. The reconstituted frozen orange juice after supplementation with egg contained less than 1,000 bacteria per g. in 7 of 9 samples and less than 10,000 in the other two. One of 2 samples of fresh orange juice analyzed contained a high bacterial count. Freezing and storage of orange juice reduces bacterial count appreciably according to Hahn and Appleman *(7)*. Holding the orangegg at 45° F. for as long as 48 hours resulted in no change in appearance, odor or increase in bacterial content (Figure 1).

However, when the orangegg was held at room temperature it generally became sour within 24 hours and the bacterial content increased rapidly during the first 24 hours of the 48 hour holding period (Figure 1). Similar observations have been reported by Miller and Marstetter *(9)*. The bacteria in uninoculated samples increased from about 1,000 per g. in the beginning to about 400,000 in 24 hours and to about 250,000,000 in 48 hours when held at room temperature. The inoculated samples increased from about 500,000 per g. in the

beginning to about 100,000,000 in 24 hours and to about 630,000,000 in 48 hours.

**Staphylococci.** Only one of the 8 samples of orange juice examined for staphylococci were free from these micro-organisms. The bacteria did not increase in samples held in the refrigerator or at room temperature as long as 48 hours (Figure 2). This was true of both the inoculated and control samples. The pH of the orangegg samples, about 4.2, did not change appreciably during the holding period. The low pH and citric acid content of the orangegg probably kept the staphylococcal count low. Tanner *(13)*, Erickson and Fabian *(4)*, Hahn and Appleman *(6)* and others have reported that a pH near 4 and the presence of certain organic acids, such as citric acid, are inhibitory to the growth of staphylococci.

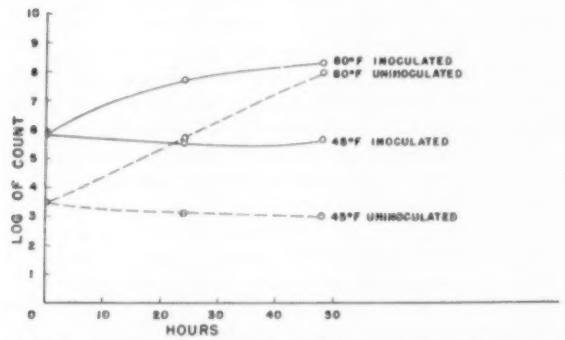


**Figure 1. Standard plate bacterial count of inoculated and uninoculated orangegg held at 80° F. (26.7° C.) and 45° F. (7° C.). Average of 7 trials.**

**Salmonellae**. Nine samples of orangegg were examined for *Salmonella* content, before and after inoculation with *Salmonella typhimurium*. None of the orangegg samples contained salmonellae before inoculation. The bacteria did not grow in inoculated orangegg samples when held in the refrigerator 48 hours (Figure 3). Some growth of *S. typhimurium* was noted, especially during the first 24 hours when the orangegg was held at room temperature (Figure 3). In 5 trials, the orangegg was inoculated not only with *Salmonella typhimurium* but also with *S. kentucky, S. oranienburg, S. pullorum* and *S. gallinarum*. Wethington and Fabian *(14)* and Ericksen and Fabian *(4)* have reported that salmonellae are even less resistant than staphylococci to low pH, as in orangegg, and to the presence of organic acids, such as citric acid, which is also present in the drink.

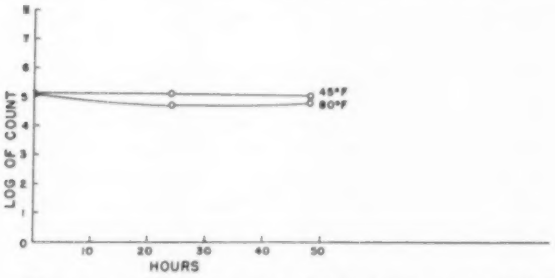


**Figure 2. Staphylococcal bacterial count of inoculated orangegg held at 80 and 45° F. Average of four trials.**

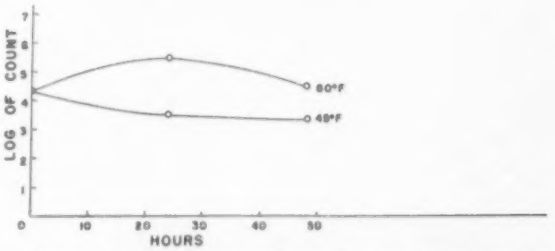


**Figure 3. Salmonella bacterial count of inoculated orangegg held at 80° F. (26.7° C.) and 45° F. (7° C.). Average of four trials.**

## SUMMARY

Orangegg was not a good medium for the growth of *Salmonella typhimurium* or *Micrococcus pyogenes* var. *aureus*.

The pH of the orangegg was 4.2 at the time of preparation and remained about the same during the holding period. The low pH and the presence of citric acid were unfavorable to the growth of *Staphylococcus* and *Salmonella* micro-organisms.

The standard plate bacterial count increased rapidly during the holding period at 80° F. (26.7° C.) but not at 38° F. (3.3° C.).

The orangegg usually became sour within 24 hours when held at 80° F. (26.7° C.).

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# Stabilized Orange Juice Powder. I. Preparation and Packaging*

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**New developments in the preparation, flavor stabilization, and packaging of powder from orange juice are described. Effects of pressure, temperature, tray loading and additives, such as corn-sirup solids, pulp or insoluble solids, orange oil and sodium bisulfite, on drying characteristics are given. Rapid drying is obtained with pressures and temperatures higher than those used in freeze drying.**

Preservation by drying, the oldest method of food preservation, has proved to be the most difficult of the several food-preservation procedures to apply to fruit juices. In spite of the work of many investigators over a period of 30 or 40 years, little progress has been made in the commercial production and marketing of fruit powders. During World War II, a spray-dried lemonade powder, containing 20% lemon-juice solids and 80% corn-sirup solids, was developed for military use. No other fruit-juice powders acceptable for military use were developed during this period, although several groups were investigating the problem *(4)*. Later, Holzcker *(16)* prepared an orangeade powder by spray drying which contained 25% orange-juice solids and 75% corn-sirup solids. A powder of this type is available commercially at this time. Much of the research on fruit powders has been directed toward the preparation of powdered orange juice.

Orange juice or orange juice concentrate has been dried, usually with drying aids, by drum drying, spray drying, and by freeze drying. Drying aids were used to promote drying, to counteract hygroscopicity of the dried product, and to reduce the tendency of the powders to cake during storage. However, some of the drying aids used introduced foreign flavors or they were used in such large proportions as to alter the nature of the product.

Drum drying yielded products which reconstituted with difficulty; the method was judged unsuitable for preparing acceptable orange-juice powders for beverage use *(21)*.

Description of spray driers and principles of operation have recently been reviewed by several authors *(19, 20, 28)*. Braverman, in evaluating orange-juice processing operations, felt that spray drying offered little hope for producing a satisfactory orange-juice powder *(2)*. Similar conclusions were drawn at this Laboratory from data obtained from numerous spray-drying experiments. Although it was found that methocel *(7)* and glyceryl monostearate *(30)*, in concentrations as low as 1% on a total-solids basis, proved to be good drying aids for spray drying orange juice, low yields, flavor changes during drying, and reconstitution difficulties were not resolved.

Freeze drying was explored during World War II for orange juice but no commercial powders resulted *(4)*. Flosdorf utilized techniques developed in freeze drying blood plasma for producing orange-juice powders. His comprehensive studies include details of principles, apparatus, methods, and cost analyses *(8, 9)*. Excellent powders were obtained from single-strength juice, but powders prepared from orange-juice concentrates lacked flavor. Powders prepared by freeze drying reconstituted readily but showed a tendency to coalesce *(10)* and develop off-odors during storage. Economic considerations of high production costs and large capital investments have deterred commercial exploitation of freeze drying for manufacture of orange-juice powder.

"Puff drying" is the name the present authors selected for the method of dehydrating liquid materials in vacuum by evaporating water from the liquid state under pressures in excess of 1 mm. of Hg (as distinguished from freeze drying) in such a manner that the products puff during drying and form expanded, honeycombed structures. In 1943, Heyman used a similar procedure for desiccation of liquid fruit mixes with added corn sirup *(15)*. Hayes and coworkers later puff-dried 50° Brix orange-juice concentrate in a laboratory vacuum oven *(12, 13)* employing an extremely low pressure of about 100 microns. Powders reconstituted readily and were judged not as good as fresh but superior to canned juices. These results encouraged further investigations by Schroeder and Cotton *(24)*, who obtained drying rates and drying curves for 50° Brix orange-juice concentrates. These powders were deficient in characteristic orange flavor *(25)* and also subject to deterioration during storage at temperatures above 80° F. (27° C.). An attempt was made at a later date to improve storage stability by in-package desiccation *(5)*.

A commercial plant was designed and constructed with a capacity of 5,000 lbs. of orange-juice powder per 24 hours *(22, 26, 27)*, and a distributorship was established for sale of orange juice powders to foreign markets *(3)*. At this point, the company embarked into the newly developed frozen concentrate field, and production of orange-juice powder came to a complete halt.

In 1947 Sluder described the construction and operation of a continuous belt-type dehydrator designed specifically for orange-juice desiccation *(29)*. It consisted simply of an endless stainless-steel belt housed within an evacuated chamber. Radiant heat was used for drying thin moving films of orange-juice concentrate. The concentrated orange juice puffed while

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drying. Dried material was cooled and then removed from the belt by a doctor blade. The product would probably have been more promising if high-vacuum, low-temperature concentrate, free from heat damage, had then been available. Improved continuous belt-type dehydrators, fundamentally similar in design and operation, have recently been used for dehydrating coffee.[6]

This paper reports part of an investigation on the preparation of powders from orange juice. It discusses feed preparation, drying techniques, flavor fortification, and the use of in-package desiccation to improve storage stability. Chemical and organoleptic evaluations and other results of the storage study will be reported in another paper.

## MATERIALS USED

**Concentrated orange juice.** High-density concentrates containing 60 to 65% soluble solids were obtained directly from plants in California and Florida that produce frozen concentrated orange juice. Sugar-acid ratio varied from 12:1 to 15:1 and the amount of oil in the concentrate (single-strength basis) ranged from 0.002 to 0.003% *(6)*. The pulp contents varied from 9 to 13% by volume when tested as described earlier. Although the flavors of the various concentrates used have been variable, the drying properties and puffing characteristics of all samples have been satisfactory.

**Corn-sirup solids.** Low-conversion spray-dried corn-sirup solids of about 24 dextrose equivalent (DE) were used as drying aids in some of the experiments to reduce hygroscopicity of the orange solids. Use of corn-sirup solids with a higher DE may impart undesirable sweetness to the product, particularly if the concentrate has a high sugar-acid ratio. Samples of corn-sirup solids used contained several parts per million of iron and copper but no adverse effects on storage stability or vitamin retention were noted.

**Orange oil.** Both terpeneless and cold-pressed peel oils have been used in these experiments to provide characteristic flavor lost during concentration. Various commercial samples were evaluated organoleptically on the basis of characteristic odor and flavor they imparted to reconstituted orange powder. In the samples tested, cold-pressed peel oils were generally preferred to terpeneless peel oils.

## PREPARATION OF ORANGE POWDER

In our experiments, preparation of orange powder has been carried out batchwise in a conventional vacuum-shelf drier fitted so that steam, hot water, or cold water could be circulated through the shelves. The vacuum source consisted of a 3-stage steam ejector capable of maintaining pressures down to 1 mm. of Hg.

Concentrated orange juice containing at least 60% soluble solids has been found to be the most satisfactory feed material. The concentrate was prepared in low-temperature evaporators and was free from heat-induced and other foreign flavors. Such concentrate is available commercially from plants producing frozen concentrated orange juice, since the juice is normally concentrated to about 60° Brix and then "cut back" with single-strength juice to give the familiar four-fold concentrate containing about 42% soluble solids.

[6] Procedures for vacuum evaporation of food products under conditions that cause puffing are included in several patents. Interested manufacturers should consider the impact of these patents on their contemplated operations. The following list of U. S. patents does not include those entered under Literature Cited on a later page. Moreover, it does not represent an exhaustive search. There may be others that include puff-drying procedures: Washington, 1,512,731, Oct. 21, 1924; Moore, 1,543,948, June 30, 1925; Pierce, 1,556,572, Oct. 6, 1925; Twight, 1,624,153, Apr. 12, 1927; Moore, 2,023,536, Dec. 10, 1935; Moore, 2,091,372, Aug. 31, 1937; Webb, 2,110,184, Mar. 8, 1938; Heyman, 2,328,554, Sept. 7, 1943; and Shepard 2,400,845, May 21, 1946.

This concentrate was flowed evenly over the surface of shallow stainless-steel trays (1 x 3 ft.) so as to obtain a film approximately one-sixteenth inch deep or a tray loading of 0.5 lb. per square foot. The trays were then placed on the shelves of the drier, the door closed, and the pressure reduced. It was found that the shelves could be preheated when loading the drier but loading should be completed promptly, and at this stage the temperature of the concentrate should not be allowed to rise much above 100° F. (38° C.). The vacuum source should be adequate to reduce the pressure within the chamber below 10 mm. of Hg in 3 or 4 minutes. Otherwise heating the shelves should be postponed until this pressure has been attained. The medium in the shelves can then be adjusted to the desired temperature.

During the early stages of drying, evaporation of water was quite rapid and the temperature of the concentrate dropped considerably below room temperature. Temperatures encountered in a typical drying cycle in which the shelves were preheated to 200° F. (93° C.) and maintained at that temperature during the early stages are shown in Figure 1. It will be noted that, following an initial rise of about 25° F. (14° C.) before the pressure was reduced, the temperature of the product dropped rapidly to about 35° F. (1.7° C.) and then began to rise somewhat less rapidly after approximately 10 minutes. Shortly after drying began, there was an evolution of gases, partly due to deaeration and partly to ebullition. Because of the viscosity of the concentrate, there was no spattering with loss of orange solids. Evolution of gases caused the concentrate to swell or puff in a manner somewhat similar to the leavening of bread, although in the earlier stages of dehydration there was visible evidence of gas evolution from the progressively thickening feed. During this interval of 15 to 20 minutes the product remained below 100° F. (38° C.). As drying progressed, the concentrate assumed the appearance of a solid and there was a sharp decrease in rate of evaporation of water, which necessitated a decrease in shelf temperature to avoid overheating the product. Shelf temperature was gradually reduced as the product temperature increased so that after 90 minutes of drying time both product and shelf temperature were near 140° F. (60° C.).

It was found that reasonably uniform pressures should be maintained in the drying chamber during the drying cycle, since an increase in pressure of as much as 5 mm. of Hg may cause the partially dried product to collapse and the sponge-like structure, which promotes rapid drying, will be lost. A sharp concurrent rise in product temperature indicative of lowered evaporation rate also occurs and may result in heat damage to the product. If drying has not proceeded too far when loss of structure occurs, puffing may recur when normal operating conditions are restored.

After 90 to 100 minutes, the product normally contained about 3% moisture and was cooled to below 90° F. (32° C.) by lowering the temperature of the circulating medium in the shelves of the drier. The vacuum was then released by air and

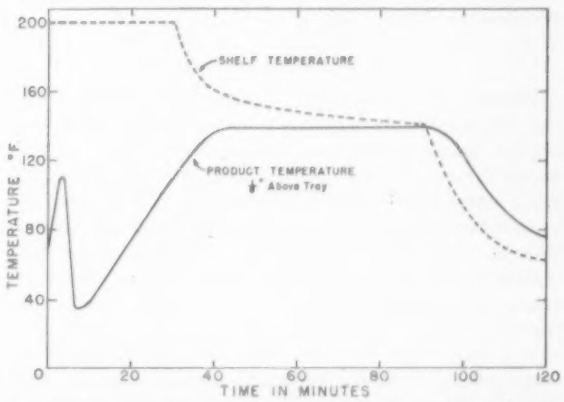


**Figure 1. Time-temperature cycle for converting 60° Brix orange concentrate into orange powder (3% moisture content) using a tray loading of 0.5 lb. per ft.² and 2 mm. Hg.**

the trays were removed from the drier. If the vacuum is released without cooling of the product, the material may partially collapse and its sponge-like structure be lost, since the material is still thermoplastic at higher temperatures.

The feed, originally only one-sixteenth of an inch in thickness, has now expanded in volume about 15 to 20 times and is now one to two inches in thickness. After cooling, the product is quite friable and can be easily removed from the trays. A silicone coating on the trays facilitates product removal. Since orange solids are quite hygroscopic, the material was handled after removal from the drier in a room maintained at not more than 15% relative humidity to avoid moisture uptake.

It is quite important that the feed be uniformly distributed over the trays and that bottoms of trays be reasonably flat. Under these conditions, heat conduction from shelf to tray will be more uniform and no unpuffed or wet areas should be found.

Owing to the sponge-like structure of the puffed orange solids (Figure 2), they are quite friable and can be easily reduced to a powder in crushing or grinding equipment. Comminuting to a fine powder (less than 100 mesh) gives a product of high bulk density but one which reconstitutes with some difficulty. Comminution so that all particles will pass 10 mesh and 50% by weight will be retained on 20 mesh gives a powder of intermediate bulk density (0.3 to 0.4 g./ml.) which reconstitutes almost instantaneously when added to water. A solution made by adding one volume of this fruit powder without additives to 3 volumes of water contains about 12% orange solids.

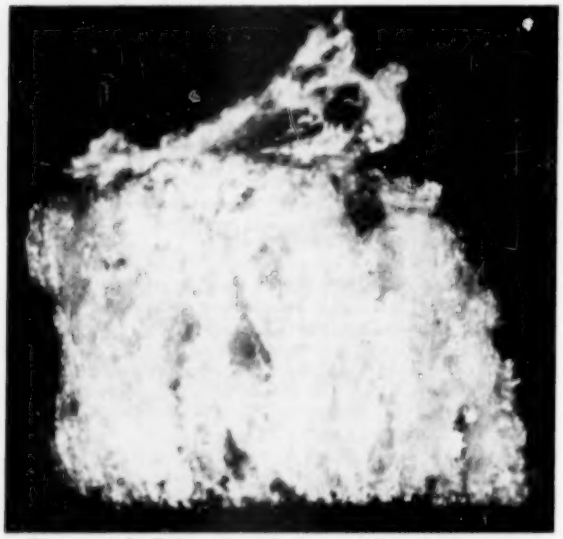

**Figure 2. Puffed section of orange solids showing sponge-like structure (natural size).**

## FACTORS AFFECTING DRYING

**Pressure.** The drying procedure outlined above employs liquid-film drying so as to obtain puffing of the feed during drying and can be carried out at considerably higher pressures than those (about 1 mm. of Hg or less) required for freeze drying. Orange concentrate can be satisfactorily dried under pressures in the drying chamber up to about 4 mm. of Hg. At higher pressures, puffing during drying is not uniform. Where expansion does not occur during drying, the thin layer of concentrate contracts to a hard film which is only partially dry at the end of the cycle and can be removed from the trays only with great difficulty. A little more rapid drying and somewhat greater expansion may be obtained at a pressure of 1 to 2 mm. of Hg, but there seems to be little advantage in these low pressures.

Results obtained indicate a certain critical pressure near 4 mm. of Hg, which cannot be exceeded if satisfactory puffing is to be consistently obtained. A comprehensive study of the factors that affect expansion of feed during drying now under way is designed to furnish information that may permit use of somewhat higher pressures.

From an economic standpoint, dehydration should be effected at the highest pressures feasible, since steam costs, as well as equipment costs, mount quite rapidly where pressures below 4 mm. are employed.

**Temperature.** Desiccation should be carried out in a time-temperature cycle that will not result in heat damage to the product. Safe product temperatures cannot be given for the process without due consideration to time the product is held at a given temperature and perhaps even the moisture content of the orange solids at that time. It has been found that 140° F. (60° C.) is a safe finishing temperature for the cycle and that the orange solids can be held at this temperature 50 to 60 minutes with little heat damage. It has also been found that considerably higher product temperatures can be safely employed to shorten the drying cycle, provided the equipment permits sufficient rapid cooling so that the orange solids are not held too long at these higher temperatures. Data, however, are too limited to permit more definite statements about safe time-temperature schedules. Shelf temperatures as high as 275° F. (134.5° C.) have been used safely during the early stages of drying with no evidence of product deterioration.

**Soluble solids in feed.** The feed should contain at least 60% soluble solids; otherwise, spattering and loss of solids occur during the early stages of dehydration. Feeds containing 70% soluble solids are preferable, provided they are sufficiently fluid to flow evenly on trays. These feeds not only contain less water per pound of orange solids but they puff more uniformly during drying. However, no commercial orange concentrate prepared in low-temperature evaporators has been found that contains more than 65% soluble solids, presumably because of difficulties in handling the viscous concentrate.

**Pulp or insoluble solids in feed.** Excessive pulp in the feed inhibits or even prevents puffing during dehydration. Concentrates which contain not more than about 12% pulp by volume (tested after reconstitution to 12% soluble solids by centrifuging at 2,000 r.p.m. for 30 minutes in a centrifuge 10 inches in diameter) have dried satisfactorily. All commercial samples of concentrated orange juice (60° Brix or higher) have been satisfactory in this respect, since in most if not all plants a large part of the pulp in the juice is removed prior to concentration in order to obtain a more fluid product and reduce handling problems.

Undoubtedly particle size as well as amount of suspended solids is also a factor in determining the way a concentrate will dry, but no data are available.

**Additives.** Several substances, including corn-sirup solids, sodium bisulfite, orange pulp or insoluble solids, and orange oil have been added to the feed prior to drying. These have been added to the concentrate with

sufficient mechanical stirring to insure homogeneity of the feed.

Low-conversion spray-dried corn-sirup solids (24 DE) have been added to concentrated orange juice (60° Brix) in various amounts so as to give up to 60% orange solids and 40% corn-sirup solids in the feed. While this feed is quite viscous, it can be handled without great difficulty. It puffs and dries somewhat more readily and quickly than concentrated orange juice alone. Incorporation of corn-sirup solids in this manner reduces the hygroscopicity of the resulting powder.

Pulp or insoluble solids in the form of reasonably intact juice sacs obtained from the finishing operation in an orange concentrate plant have been added to 60° Brix orange juice concentrate to the extent of about 15% by weight without excessive inhibition of puffing during dehydration. Upon reconstitution, such orange powder has the pulpy quality of fresh juice.

Addition of 0.1% orange oil or sodium bisulfite up to 250 p.p.m. (as $SO_2$) based on solids in feed, had no perceptible effect on the drying characteristics. Sodium bisulfite was used as a means of increasing storage stability. Its effect is discussed in another paper.

**Effect of air in feed.** Excessive incorporation of air in feed, such as may result during the mixing of corn-sirup solids with the concentrate, may cause excessive puffing and some loss of solids during early stages of dehydration. Deaeration can be satisfactorily effected by controlling rate of evacuation of dryer or by deaeration in a suitable conventional type of deaerator.

**Effect of tray loading.** Tray loadings of 0.25, 0.5, 0.75, and 1.0 pound of concentrate per square foot of drying surface have been used to determine optimum drying conditions. Drying times of about 45 minutes were required for 0.25 lb./ft.$^2$; 90 minutes for 0.5 lb./ft.$^2$; 120 minutes for 0.75 lb./ft.$^2$; and about 150 minutes for 1.0 lb./ft.$^2$ tray loading. These times were required to reduce the moisture content of a 65° Brix feed to 3% with an initial shelf temperature of 200° F. and about 2 mm. Hg pressure. Powders prepared with tray loadings of 1.0 lb. per square foot were inferior in flavor to other samples, presumably because of heat damage resulting from the additional time required for drying.

## INCORPORATION OF FLAVOR

Practically all of the characteristic flavor of orange juice has been shown to be derived from oil from the peel which is incorporated in the juice during extraction *(1, 23)*. This oil is volatile and is largely lost during the two concentrating steps involved in the preparation of orange powder. Essential oil must be returned to the powder; otherwise the reconstituted juice lacks flavor. Sufficient oil is added so that the reconstituted juice contains 0.006 to 0.01% of recoverable oil *(6)*.

Two methods have been used for adding orange oil to the powder. Sufficient oil, either cold-pressed or terpeneless, was added directly to the feed, prior to dehydration to powder, so as to give the desired flavor to the product. Approximately one-fifth of the added cold-pressed peel oil was lost in drying while very little terpeneless oil was volatilized. Oil added to orange powder in this manner is very effectively exposed to the action of oxygen and undergoes the usual oxidative and other deteriorative changes that might be expected.

A process for incorporating oils and related products into sorbitol *(11)* has recently been developed. This procedure has been used to increase the stability of orange oil for addition to powder. In this process, orange oil was added slowly with rapid stirring to molten sorbitol which had been heated to about 392° F. (200° C.) to remove water and then supercooled to about 194° F. (90° C.). Up to 10% by weight of oil can be added to the sorbitol. The emulsion of oil in liquid sorbitol was then allowed to crystallize and broken into granules of about 10 to 20 mesh. Small particles are not desirable, since each new surface exposes additional oil to the air. The sorbitol-oil granules were then added to the powder just prior to packaging.

Where flavor is to be incorporated into orange powder as sorbitol-oil granules, the concentrated orange juice used in preparing the feed should contain a minimum amount of oil so that a maximum amount of stabilized oil in sorbitol-oil granules can be added to the powder.

## IN-PACKAGE DESICCATION

In-package desiccation, developed at this Laboratory during World War II for increasing the storage stability of dehydrated vegetables *(17, 18)*, appears to be indispensable in the preparation of stable orange powder. Not only does it permit the extremely low moisture contents necessary to impart storage stability to orange powder, but, by supplying an alternate means of reducing moisture content to less than 1%, it makes possible the reduction of time in the vacuum drier by at least 75% with a consequent several-fold increase in capacity.

In-package desiccation is accomplished by sealing orange powder containing about 3 to 4% moisture in a hermetic container with a quantity of desiccant sufficient to absorb substantially all of the residual moisture in the powder. The desiccant is enclosed in a sift-proof, moisture-permeable paper container which permits transfer of water vapor from the product to the desiccant but does not allow the desiccant to contaminate the product. A patent was issued to a private company in 1950 covering certain phases of in-package desiccation for citrus powders *(5)*.

The choice of the proper desiccant for in-package desiccation is very important. The desiccant selected must meet the following requirements. It must be relatively non-toxic, inexpensive, and readily available. It must have high water-sorptive capacity per unit weight and be able to maintain the relative humidity within a hermetically sealed container at virtually zero percent until saturated. Calcium oxide or calcined lime, which was described by Howard *(17, 18)*, fulfills these requirements quite satisfactorily. It reacts with 32% of its weight of water during conversion to calcium hydroxide and will maintain virtually zero humidity until completely reacted. Orange powder containing 3% water can be desiccated to substantially zero moisture content by 10% of its weight of calcined lime. Since

calcined lime increases in volume on rehydration, it is necessary to make provision for this in the construction of the desiccant container; otherwise the expanding lime will burst the container and contaminate the product. With a safe allowance for expansion, this amount of lime (10% of the weight of the orange powder) will occupy 10 to 15% of the container space.[4]

It has been found that there is a sharp reduction in rate of drying of orange powder at about 3% moisture content. Thus drying proceeds fairly rapidly up to this point but then becomes progressively slower. Orange concentrate containing 60% soluble solids can be dried to 3% moisture content in 1.5 hours and to 1% moisture content in not less than 5 hours. Removal of the product from the drier at the higher moisture level and completing desiccation within the container not only greatly reduces drying time and operational costs but, in addition, eliminates much of the danger of heat damage during drying.

Rate of in-package desiccation is increased considerably by sealing the container under vacuum, but vacuum is not essential for satisfactory results. By in-package desiccation, it has been found possible to reduce the moisture content of orange powder from 3 to 1% during storage for one month at 70° F. (21° C.) and from 3% to below 0.5% over a period of 6 months. It has been found necessary to hold samples of orange powder at about room temperature until the moisture content is reduced below 1% before subjecting them to elevated storage temperatures in order to minimize storage deterioration.

The above data have been obtained from a batch-type operation employing a conventional vacuum-shelf dryer. Application of this procedure to commercial production of orange powder may require that continuous drying equipment be used in order to avoid the high labor costs of manually loading and unloading trays.

Some preliminary experiments have been conducted with a continuous belt-type vacuum drier that has been used in commercial production of soluble coffee. Orange powder was produced both with and without drying aids under conditions that caused the concentrate to puff during drying.

## SUMMARY

Orange-juice powder with storage stability even at elevated temperatures has been prepared by dehydrating concentrated orange juice containing 60 to 65% soluble solids to a dried product with about 3% moisture in a conventional vacuum shelf drier. Drying was effected from a liquid film about one-sixteenth-inch in thickness in about 1.5 hours, with pressures considerably higher than those used by previous investigators, and in such a way as to cause the product to increase in volume about 15 to 20 times. The open porous structure obtained by drying in this manner promotes rapid drying, makes the product friable and easy to remove from the drying surface, and gives a powder that reconstitutes almost instantly.

Characteristic flavor was returned in the powder by adding orange oil, stabilized by incorporation in sorbitol, to the powder after drying or by adding orange oil directly to the feed prior to drying. Greater flavor stability is obtained through the use of granules of orange oil and sorbitol for flavor restoration.

Storage stability was obtained by packing the orange powder in a hermetic container with a desiccant which removes water from the powder during storage. By this procedure extremely low moisture contents of 1% or below, necessary for obtaining storage stability at elevated temperatures, were obtained during storage.

[4] No information is available as to the attitude of State or Federal regulatory agencies on the use of calcium oxide for desiccating food products.

### Acknowledgment

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# Stabilized Orange Juice Powder. II. Changes During Storage

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**Results of a storage study on orange powder containing added corn sirup solids prepared by a vacuum drying procedure are reported. Effects of atmosphere, type of oil, method of oil addition, in-package desiccation, and added sulfur dioxide on storage stability at 70° F. (21° C.), 90° F. (32° C.), and 100° F. (38° C.) are reported.**

This paper reports results of a storage study on orange powder prepared according to a procedure described by Strashun and Talburt *(9, 10)*. As described in these papers, the orange powder was dried in a vacuum shelf drier under prescribed conditions of temperature and pressure. The feed contained 60% orange-juice solids and 40% low-conversion corn-sirup solids. It was prepared by mixing the required amount of corn-sirup solids with a commercial orange juice concentrate (58° Brix) prepared from California Valencia oranges in a low-temperature evaporator. The concentrate was obtained directly from a manufacturer and had not been heat stabilized. Volatile flavor lost during evaporation was replaced by addition of commercial cold-pressed or terpeneless peel oil to the feed prior to drying, or was added to the dry powder in the form of an emulsion of orange oil and solid sorbitol as previously described *(3, 10)*. Pressure was maintained at 4 mm. of Hg in the drier and product temperature was not permitted to rise above 140° F. (60° C.). In-package desiccation with recalcined lime (CaO) in a perforated metal container, as previously described *(10)*, was used to increase storage stability of most of the samples. Table 1 shows the composition of the concentrated orange juice and corn-sirup solids used in preparing the samples.

The storage study was designed to show the effects of atmosphere, storage temperature, type of orange oil, method of adding oil, in-package desiccation, and added sulfur dioxide. Table 2 shows the types of samples included in the study and the storage temperatures used. Approximately 750 samples were packed, which permitted between 12 and 15 samples for each variable at each of the 3 storage temperatures. In addition, approximately 20 control samples for each variable were packed under vacuum without in-package desiccation and stored at —30° F. (—34° C.).

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**TABLE 1**
**Analytical data on raw materials used in orange powders**

| California Valencia orange juice concentrate [c] | | Corn-sirup-solids powder [d] | |
|---|---|---|---|
| Total solids | 57.9% | Dextrose | 21.4% |
| Ascorbic acid | 173 mg./100 g. | Maltose | 20.2% |
| Sugar, total (as glucose) | 42.0% | Higher sugars | 19.5% |
| Sugar, reducing (as glucose) | 21.5% | Dextrins | 35.9% |
| Total carotenoids | 120 µg./g. | Moisture | 3.0% |
| Free titratable acidity (as citric acid) | 4.95% | Dextrose equivalent | 24.0% |
| pH (23° C.) | 3.4 | Copper [e] | 6 p.p.m. |
| Volatile oil | 0.026% | Iron [e] | 9 p.p.m. |
| Brix | 56.9° | | |

[c] Results reported on an "as received" basis.
[d] Proximate composition supplied by the manufacturer.
[e] Analysis made at Western Regional Research Laboratory.

Samples were packed in 12-ounce sanitary-type enameled cans (211 x 414), each containing 170 g. of powder. The desiccant unit contained sufficient recalcined lime (CaO) to react with all water in the sample and was packed in metal ointment boxes with perforated lids. Water-vapor-permeable paper was placed underneath the lid of the ointment box to prevent sifting of lime into the orange powder. Samples with oil incorporated in sorbitol were packed with the specified weight of powder prepared without added oil and with the flavoring component placed at the bottom of the container. The containers were sealed in a semi-automatic double seamer provided with a vacuum chamber. Minimum pressures obtainable with the equipment (about 29 inches of Hg vacuum) were used for vacuum packing of samples.

All samples, other than control samples which were held at —30° F. (—34° C.), were stored at 70° F. (21° C.) after packing was completed. At the end of 75 days samples to be stored at 90° F. (32° C.) and

**TABLE 2**
**General information on storage study**

| Types of powders stored | Types of orange oil used | Can atmosphere | Storage temperatures (° F.)[g] | | |
|---|---|---|---|---|---|
| Nondesiccated, nonsulfited | cold-pressed | air, vacuum | 70 | 90 | 100 |
| Nondesiccated, sulfited | cold-pressed | air, vacuum | 70 | 90 | 100 |
| Desiccated, nonsulfited | no oil added | vacuum | 70 | | 100 |
| Desiccated, nonsulfited | terpeneless | air, vacuum | 70 | | 100 |
| Desiccated, nonsulfited | cold-pressed | air, vacuum | 70 | 90 | 100 |
| Desiccated, nonsulfited | cold-pressed [f] | vacuum | 70 | | 100 |
| Desiccated, sulfited | no oil added | vacuum | 70 | | 100 |
| Desiccated, sulfited | terpeneless | air, vacuum | 70 | | 100 |
| Desiccated, sulfited | cold-pressed | air, vacuum | 70 | 90 | 100 |
| Desiccated, sulfited | cold-pressed [f] | vacuum | 70 | | 100 |

[f] Cold-pressed orange oil in sorbitol.
[g] All control samples were vacuum packed without desiccants and stored at —30° F.

100° F. (38° C.) were then removed to their respective elevated-storage temperatures. Samples were stored at 100° F. (38° C.) for 6 months; at 90° F. (32° C.) for 9 months; and at 70° F. (21° C.) for one year. This conditioning period of 75 days at 70° F. (21° C.) permitted the moisture content of the samples with in-package desiccants to be reduced from an initial value of about 3% to about 1.5% before being subjected to elevated storage temperatures.

Samples were removed from storage periodically for chemical and organoleptic tests. Powders stored at 100° F. (38° C.) were assayed after 1, 2, 4, and 6 months of storage; those stored at 90° F. (32° C.) and 70° F. (21° C.) were examined at less frequent intervals.

## METHODS

**Chemical analyses.** Atmospheres of air-packed samples were analyzed for oxygen and carbon dioxide with a modified Orsat gas analyzer. Vacuum measurements were made routinely on vacuum-packed samples with a puncture-type canners' test gage to detect any leakage during storage.

Usually 3 cans of powder per variable were required for tests made at each sampling period. The contents of these containers were composited, thoroughly mixed, and representative subsamples were removed from the various scheduled assays. Some of the samples packed without in-package desiccants caked badly during storage. These were pulverized with mortar and pestle prior to sampling. All powders were sampled in a low humidity room maintained at about 5% relative humidity in order to minimize changes in moisture content during sampling.

The moisture content of the powders was determined in a vacuum oven with a shelf temperature of 140° F. (60° C.) for a 30-hour drying period. Initial and terminal moisture contents of powders were also determined by the Karl Fischer method as modified by McComb and McCready *(7)*. Ascorbic acid was determined by the Loeffler and Ponting method *(6)*. Reductones were determined by the method of Wokes *et al. (11)*. Sulfur dioxide was assayed by the gravimetric method of Monier-Williams *(8)*. Recoverable oil was determined in a modified form of the McKinnis *(2)* apparatus. Reducing and total sugars were determined only in the concentrate by a modification of the cerate oxidimetric method *(4)*.

Carotenoids were assayed by separating the suspended material from the water-soluble fraction of the juice. The carotenoids were extracted from the suspended material with acetone, transferred to petroleum ether, and the optical density of the solution was determined colorimetrically using a 440 mμ filter. This was read as β-carotene from a calibrated curve prepared from pure β-carotene.

Extent of non-enzymatic browning was determined by a modification of a procedure developed by Hendel *et al. (5)*. It is expressed as the optical density of the clarified extract obtained from a 5% aqueous solution of orange powder and measured in a 2-cm. absorption cell with a 420-mμ filter.

**Organoleptic methods.** Orange powders were reconstituted by adding 4 parts of distilled water at room temperature to one part of powder by weight. The resulting juice contained 12% orange solids and 8% corn-sirup solids. Choice of this dilution was somewhat arbitrary and the resulting juice was thought by some panel members to be a little too sweet and sirupy. Samples were appraised both by triangle taste tests and by scoring procedure in a tasting booth illuminated in such a manner as to mask color differences. The former method was used for comparing 2 samples where only minor differences were anticipated, as in comparing the feed material with the powder prepared from this feed in order to ascertain flavor changes during processing. In other instances, the 10-membered panel was presented with as many as 5 samples per sitting and asked to score the samples for palatability, using a 10-point scale with 10 being *highly palatable*, 6 the *limit of palatability*, and one designated as *extremely unpalatable*. Paired samples were used to ascertain effects of added sulfite. All panel members had previous experience on taste panels. They were selected after a preliminary educational and testing program designed to test their ability to recognize flavor changes developed in stored powders. All samples, including controls, were coded so that panel members did not know which samples were being tasted. The large number of variables included in the study permitted not more than 2 replications (20 judgments) in any of the comparisons and in some cases was limited to a single panel evaluation. Where scoring procedures were used, insufficient data for statistical analysis were obtained and all conclusions drawn from the tests were based on inspection of arithmetical averages.

## RESULTS

**Changes during processing.** Results obtained from the chemical analyses of the various feeds and powders prepared are given in Table 3. Losses of carotene and ascorbic acid during drying were small. Small consistent losses of oil and sulfur dioxide were also found. No evidence of non-enzymatic browning, as measured by optical density of clarified aqueous extracts, was found during drying.

Organoleptic comparison of feeds and corresponding powders by triangle taste tests showed that the panel could distinguish between these samples and that, in general, they preferred the feeds. Since a part of the oil contained in the feed is lost during vacuum drying, it was thought that the preference of the panel might be due to the slightly higher oil content in the feed. To check this, sufficient cold-pressed oil was added so that reconstituted feed and powder contained the same percentage of oil and were again compared by triangle taste test. In this comparison the panel preferred the juice prepared from the powder.

**Changes during conditioning period.** Although the conditioning period used, 75 days of storage at 70° F.

**TABLE 3**

**Chemical analyses of feeds and freshly prepared orange-juice powders**

| Type of feed or powder[a] | Total solids of feed AR[b] % | Moisture content of powder AR % | Ascorbic acid mg./100 g. MFB[c] | | | Total carotenoids μg./g. MFB | | | Residual $SO_2$ p.p.m. MFB | | | Optical density[d] | | Volatile oil, MFB ml./kg. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Feed | Powder | % Retention | Feed | Powder | % Retention | Feed | Powder | % Retention | Feed | Powder | Feed | Powder |
| No oil, no $SO_2$ | 71.3 | 3.1 | 188 | 194 | 103 | 122 | 116 | 95 | — | — | — | 0.08 | 0.08 | 0.2 | 0.2 |
| No oil, $SO_2$[e] | 71.3 | 3.0 | 209 | 194 | 93 | 119 | 115 | 97 | 229 | 222 | 97 | 0.07 | 0.08 | 0.2 | 0.2 |
| T oil, no $SO_2$ | 69.8 | 2.1 | 201 | 191 | 95 | 123 | 112 | 91 | — | — | — | 0.08 | 0.08 | 0.6 | 0.5 |
| T oil, $SO_2$ | 70.5 | 2.3 | 212 | 189 | 89 | 117 | 111 | 95 | 243 | 206 | 85 | 0.07 | 0.08 | 0.7 | 0.6 |
| CP oil, no $SO_2$ | 69.8 | 3.0 | 203 | 184 | 91 | 123 | 114 | 93 | — | — | — | 0.08 | 0.08 | 0.7 | 0.6 |
| CP oil, $SO_2$ | 70.5 | 3.1 | 190 | 194 | 102 | 120 | 118 | 98 | 246 | 229 | 93 | 0.07 | 0.08 | 0.7 | 0.5 |

[a] Explanation of codes: T oil, terpeneless oil; CP oil, cold-pressed oil; No $SO_2$, nonsulfited; $SO_2$, sulfited.
[b] AR = as received basis.
[c] MFB = moisture-free basis.
[d] Optical density = 5 g. orange powder (MFB) per 100 ml. water, 2-cm. cell, 420-mμ filter.
[e] Added as sodium bisulfite.

(21° C.), is obviously part of the room-temperature-storage study, it seems advisable to discuss this separately, since the conditioning period is absolutely essential in achieving storage stability at elevated temperatures through the use of in-package desiccation. This conditioning period permitted reduction of moisture content from an initial value of about 3% to 1.4 and 1.7% for vacuum- and air-packed samples, respectively.

During this period non-enzymatic browning, as measured by optical density of water-soluble pigments, and losses of ascorbic acid were extremely slow in all samples regardless of package atmosphere, sulfite content, or moisture content. By contrast, losses of carotenoid pigments occurred rather rapidly in all samples during the conditioning period, amounting to about 18 to 27% of the total during this period.

At the end of the conditioning period samples stored at 70° F. (21° C.) were compared by triangle taste tests with the corresponding control sample stored at −30° F. This procedure was used since the differences between samples being compared were so slight that scoring procedures would not be practicable. In general, it was found that the panel could distinguish between the samples stored at −30° F. (−34° C.) and those stored at 70° F. (21° C.) for 75 days and that they preferred the control samples (Table 4). It should be

**TABLE 4**
**Comparison of juices from "conditioned" [m] and control [n] samples by triangle taste tests**

| Description of sample [o] "conditioned" sample vs. control | Number of judgments | Correct answers | Probability [p] | Number preferring | |
|---|---|---|---|---|---|
| | | | | Control | Conditioned |
| No oil, no $SO_2$, vacuum | 18 | 12 | .01 | 9 | 2 |
| No oil, $SO_2$, vacuum | 20 | 14 | <.01 | 8 | 3 |
| T oil, no $SO_2$, air | 20 | 10 | >.05 | 9 | 1 |
| T oil, $SO_2$, air | 20 | 7 | >.05 | 2 | 3 |
| CP oil, no $SO_2$, air | 20 | 18 | <.01 | 15 | 3 |
| CP oil, no $SO_2$, vacuum | 20 | 11 | .05 | 7 | 2 |
| Sorbitol, no $SO_2$, vacuum | 20 | 11 | .05 | 8 | 1 |
| Sorbitol, $SO_2$, vacuum | 20 | 13 | .01 | 9 | 1 |

[m] Conditioned samples were held at 70° F. for 75 days.
[n] Control samples were held at −30° F.
[o] All samples were reconstituted to a 12% orange-juice solids basis.
[p] Probability of 0.05 or less means statistical difference between samples.

borne in mind that the differences found between controls and stored samples, though statistically significant, are very small, since the triangle test is designed to measure very small differences.

**Post-conditioning storage changes.** Changes in ascorbic acid, carotenoids and moisture contents and extent of non-enzymatic browning are shown in Figures 1, 2, 3, and 4, respectively. Only data for samples containing cold-pressed oil added directly to the feed are presented, since similar results were found in samples containing no added oil, terpeneless oil, and oil incorporated in sorbitol.

Changes in moisture content of desiccated samples during storage are shown in Figure 1. As expected, higher temperatures and vacuum packing accelerated the rate of desiccation. At 100° F. (38° C.) the moisture content of vacuum-packed samples was reduced from 1.4 to 0.5% in 28 days and to 0.3% in 60 days, while at 70° F. (21° C.) this type of sample still contained 0.6% moisture after about 300 days. Rates of

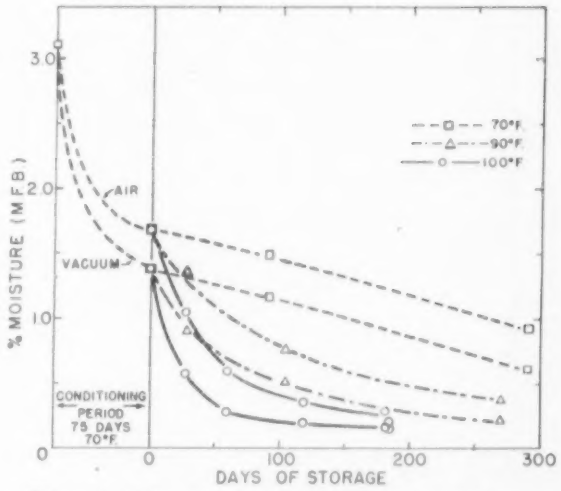


**Figure 1. Effect of storage temperature and package atmosphere on rate of in-package desiccation of orange powder.**

desiccation at 90° F. (32° C.) were intermediate between those at 100° F. (38° C.) and 70° F. (21° C.). Samples packed without desiccants showed an increase in moisture content, 0.3% during 6 months' storage at 100° F. (38° C.), presumably through decomposition and interaction of amino acids and sugars or other constituents. Results obtained by the Karl Fischer method were in general 0.2 to 0.3% higher than those obtained with the vacuum oven method used.

Changes in ascorbic acid content of both desiccated and non-desiccated samples during storage are shown

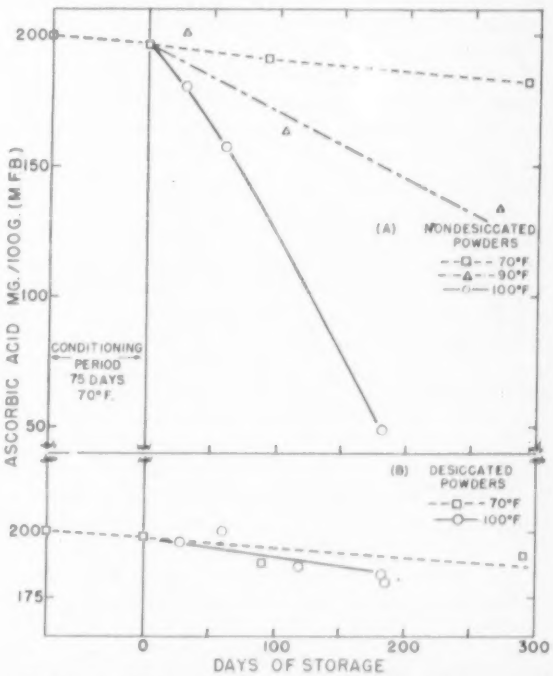


**Figure 2. Effect of in-package desiccation upon ascorbic acid content of non-sulfited air-packed orange-juice powder stored at 70°, 90°, and 100° F.**

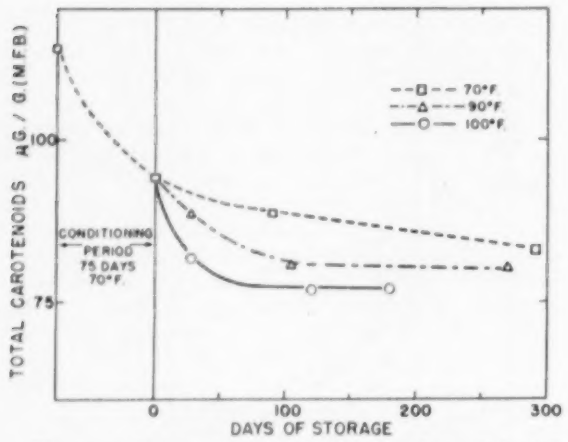


**Figure 3. Losses of carotenoids in in-package desiccated samples of orange powder during storage.**

in Figure 2. The low moisture contents, achieved by in-package desiccation, provided protection against loss of ascorbic acid in all samples, whereas samples without desiccants showed substantial losses up to 75% of ascorbic acid present during 6 months of storage at 100° F. (38° C.). Losses of ascorbic acid in all desiccated samples were unimportant, amounting to only 10% of that present under the worst condition, i.e., 100° F. (38° C.) storage for 6 months.

Data on carotenoid stability (Figure 3) show carotenoid losses of desiccated samples at 70° F. (21° C.), 90° F. (32° C.), and 100° F. (38° C.). Losses followed the same general pattern for any given temperature in both desiccated and non-desiccated samples. Vacuum packing or sulfite addition afforded little protection against carotenoid losses.

Extent of non-enzymatic browning as measured by increase of optical density of clarified aqueous extracts of the stored powders are shown in Figure 4. In-package desiccation was extremely effective in preventing this type of undesirable change even in powders stored at 100° F. (38° C.) where only very small changes in optical density were found. These changes were so small that they were not discernible visually in the reconstituted powders. Darkening in non-desiccated samples held at higher temperatures was quite pronounced; sulfur dioxide retarded only slightly the rate of darkening. The rate of browning in non-desiccated samples was independent of the atmosphere of the pack.

Losses of sulfur dioxide amounted to only about 20 to 30% in the desiccated samples during the storage periods but were much higher, ranging from 60 to 90%, in non-desiccated samples.

All desiccated powders remained free-flowing and free from caking throughout the storage period. Non-desiccated samples caked badly at elevated temperatures with slight caking at 70° F. Considerable carbon dioxide was evolved in non-desiccated samples and some oxygen was taken up during storage. No data on carbon dioxide evolution were obtained from in-package-desiccated samples, since the desiccant reacted with carbon dioxide as evolved. Rate of oxygen absorption was reduced by in-package desiccation.

Changes in organoleptic quality of samples during processing and in the conditioning period have been discussed earlier. Panel rating of various samples of stored powders packed with in-package desiccants and stored at 70° F. (21° C.) and 100° F. (38° C.) are given in Table 5 and Figure 5. It will be noted that in general samples containing oil stabilized in sorbitol were rated higher than those in which oil was added directly to the material and that cold-pressed and terpeneless oils were equally suitable for use in orange powder. The small amount of sulfur dioxide added to some of the samples (about 200 p.p.m.) was rather strikingly effective in reducing rate of deterioration during storage at elevated temperatures (Figure 5); vacuum packing was somewhat less effective. All samples with in-package desiccants, except some containing no added oil, were acceptable at the end of the storage study. Organoleptic

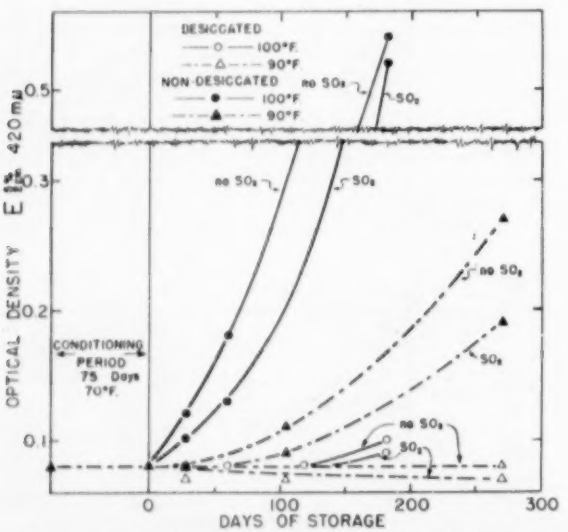


**Figure 4. Effect of in-package desiccation, temperature, and sulfite content upon browning rate of air-packed orange-juice powders.**

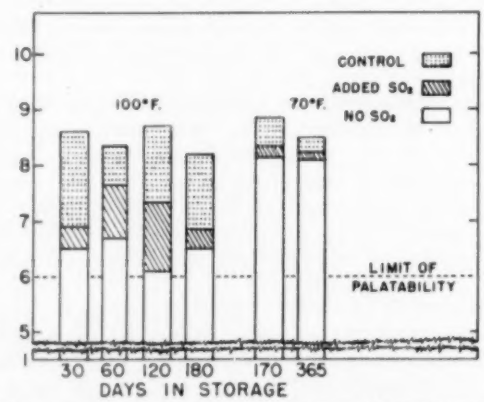


**Figure 5. Panel rating of in-package-desiccated samples stored at 100° F. (38° C.) and 70° F. (21° C.) showing effect of added sodium bisulfite (200 p.p.m. as $SO_2$). Panel rating of 10 is highly palatable; 6 is limit of palatability; and 1 is very unpalatable.**

**TABLE 5**

**Panel scores of in-package desiccated samples of orange powders stored at 70° F. (21° C.) and 100° F. (38° C.)**

| Type of sample | Organoleptic rating | | | | | |
|---|---|---|---|---|---|---|
| | Storage at 100° F.[a] | | | | Storage at 70° F. | |
| | 30 days | 60 days | 120 days | 180 days | 180 days | 360 days |
| Cold-pressed oil in sorbitol: | | | | | | |
| Sulfite added, vacuum pack | 6.9 | 7.7 | 7.4 | 6.9 | 8.4 | 8.2 |
| No sulfite added, vacuum pack | 6.5 | 6.7 | 6.1 | 6.5 | 8.2 | 8.1 |
| Cold-pressed oil added directly to feed: | | | | | | |
| Sulfite added, vacuum pack | 6.7 | 6.5 | 6.5 | 6.5 | 8.0 | 7.3 |
| No sulfite added, vacuum pack | 6.4 | 6.3 | 6.4 | 6.0 | 8.3 | 6.9 |
| Sulfite added, air pack | 6.2 | 6.0 | 6.4 | 6.2 | 7.4 | 7.0 |
| No sulfite added, air pack | 5.8 | 5.6 | 6.5 | 5.7 | 7.8 | 6.6 |
| Terpeneless oil added directly to feed: | | | | | | |
| Sulfite added, vacuum pack | 6.5 | 7.1 | 6.8 | 6.8 | 8.0 | 7.4 |
| No sulfite added, vacuum pack | 6.6 | 6.7 | 5.5 | 5.5 | 6.9 | 7.0 |
| Sulfite added, air pack | 5.4 | 6.2 | 6.1 | 6.4 | 7.5 | 7.2 |
| No sulfite added, air pack | 6.0 | 5.5 | 5.2 | 6.0 | 7.3 | 6.8 |

[a] Samples stored 75 days at 70° F. prior to placing in storage at 100° F.; rating of 10 is highly palatable; 6 is limit of palatability; and 1 is extremely unpalatable.

changes during one year of storage at 70° F. (21° C.) were very slight. At elevated storage temperatures some off-flavor formation was noted. Samples without desiccants were still acceptable after one year of storage at 70° F. (21° C.), but at 100° F. (38° C.) they caked badly, off-flavors developed, and tasting was discontinued after one month of storage.

Results (Table 5) indicate that maximum storage stability was obtained by packing sulfited samples under vacuum with an in-package desiccant and with the added oil stabilized by incorporation of sorbitol. Figure 5 shows the palatability scores of this type of material stored at 70° F. (21° C.) and 100° F. (38° C.) during the storage study. Flavor deterioration at 90° F. (32° C.) was not nearly so rapid as that found at 100° F. (38° C.).

## DISCUSSION

The results of this storage study show rather clearly the factors that contribute to storage stability of orange powder. Without doubt, moisture content of the powder during storage is the most important of these factors. Although other workers have shown that it is desirable to have a low moisture content in orange powder, they have not been able to study stability of orange powder at extremely low moisture levels because of lack of suitable procedures for obtaining such powders. For example, Cotton and Schroeder *(1)* were able to reduce the moisture content of orange powder to about 1% by in-package desiccation, but the type of desiccant employed was not suitable for obtaining the low moisture levels used in this study.

Organoleptic data (Figure 5) indicate that most of the undesirable flavor changes resulting from storage at 100° F. (38° C.) took place during the first 30 days of storage while the moisture content was being reduced from about 1.4% to 0.5% and that after this time little additional deterioration occurred. If such is the case, then it is necessary to reduce the moisture content to well below 1% in order to obtain storage stability at 100° F. (38° C.). For best results this should be done during the conditioning period and before the orange powder is exposed to high-temperature storage. An improved type of in-package desiccant unit which has a much greater surface exposed to water vapor and which takes up water vapor faster than the type used in this study is now available and is being investigated.

The presence of sulfur dioxide in small quantities in the powders was also effective in increasing storage stability. This material has been used many years to reduce the rate of non-enzymatic browning and to prolong storage life of dried fruits. On the basis of data available thus far, it is not possible to explain its role in increasing stability of the desiccated samples. In both sulfited and non-sulfited samples, visible non-enzymatic browning as measured by optical density was extremely slight. However, it is quite possible that only a very small amount of browning is sufficient to result in undesirable off-flavors or that colorless compounds formed by interaction of various constituents, and perhaps precursors to melanoidin pigments, may be responsible for the undesirable off-flavors that develop during storage at elevated temperatures. This reaction is known to be retarded by sulfur dioxide. It may be possible to obtain equal storage stability without the use of sulfur dioxide if sufficiently low moisture levels are obtained during the conditioning period and prior to storage at 100° F. (38° C.).

Another factor that was shown to affect storage stability was the method of incorporating orange oil in the powder. It is rather generally recognized that many flavoring substances, both natural and artificial, are adversely affected by exposure to air. Several procedures have been developed for adsorbing these flavors on various materials or actually encapsulating them in gelatin or similar materials. Sorbitol seems to be an excellent material for "locking-in" or stabilizing orange oil. Other procedures that are effective in excluding oxygen from the orange oil may be equally suitable.

Losses of carotenoids during storage followed a rather unusual pattern in that the losses were quite rapid initially and then exhibited rather surprising stability subsequently. This may be due to selective oxidation of the carotenoids most susceptible to oxidation, such as $\beta$-carotene, leaving the more stable compounds relatively unaffected. These changes did not appreciably alter the color of the reconstituted juice.

There is some evidence that storage stability was slightly greater in vacuum-packed than in air-packed samples. There are at least 2 explanations for the

greater stability found in the vacuum-packed samples. The most obvious is that it results from the reduced oxygen concentration within the container of the vacuum-packed samples. This might well be the true explanation, although lower concentration of oxygen did not appreciably reduce losses of carotenoid pigments, sulfur dioxide, or ascorbic acid. Increased stability may also result from the more rapid rate of in-package desiccation in the vacuum-packed samples, which permitted lower moisture levels earlier in the storage period.

## SUMMARY

Samples of orange powder prepared by a vacuum drying procedure and containing 40% added low-conversion corn-sirup solids were stored at 70° F. (21° C.), 90° F. (32° C.), and 100° F. (38° C.) and assayed periodically for chemical and organoleptic changes occurring in storage.

In-package desiccation to reduce moisture content of samples to below 1% during storage was found to be very effective in reducing flavor deterioration, undesirable color changes, and loss of ascorbic acid during storage at elevated temperatures.

Incorporation of orange oil (used to restore volatile flavors lost during processing) in sorbitol was effective in stabilizing the added oil during storage. Incorporation of small amounts of sodium bisulfite (200 p.p.m. $SO_2$ on a dry-weight basis) was effective in preventing deterioration during storage at elevated temperatures.

Samples of orange powder were still acceptable after 6 months of storage at 100° F. (38° C.) and had changed very little during one year of storage at 70° F. (21° C.).

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# Effect of Peroxidase Concentration, Acidity, and Storage Temperature on the Development of Off-Flavors in Fresh Pack Pickles[a, b, c]

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**Peroxidase activity in fresh-pack pickles is associated with the development of off-flavor and off-odor during storage. Development of such off-flavors is intensified by storage at 40° F. (4.4° C.) as compared with storage at higher temperatures. Purified preparations of cucumber and horse-radish peroxidase caused the development of off-flavors indistinguishable from those found in underpasteurized pickles.**

Previous work *(1)* has indicated that pasteurization levels adequate for the control of microbiological spoilage in fresh-pack pickles did not cause the complete destruction of peroxidase. A definite relationship was found between residual peroxidase activity and off-flavor. It was also observed that in order to prevent off-flavors caused by peroxidase activity, it was only necessary to provide sufficient heat treatment to reduce the peroxidase activity to a low level rather than to destroy it completely.

The present report provides additional data on the relation of peroxidase activity to off-flavors in fresh-pack pickles. The effect of purified preparations of cucumber and horse-radish peroxidase and liver catalase on fresh-pack pickles has been determined, and the effect of storage temperature has also been evaluated. In addition, data on the effect of acetic acid concentration on the thermal inactivation of peroxidase in cucumbers are described.

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[b] Acknowledgment is due the Glass Container Manufacturers Institute, Inc. for its interest and support in this investigation.

[c] Presented before the Thirteenth Annual Meeting of the IFT, Boston, Massachusetts, June 23, 1953.

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## EXPERIMENTAL

Standard activity curves for cucumber and horse-radish peroxidase and cucumber and liver catalase were prepared, so that the activity in subsequent experiments could be expressed as percent residual activity. Enzyme suspensions from cucumbers, horse-radish, and liver were prepared essentially as described by Appleman *(2)*. However, larger quantities of raw materials were used to insure obtaining representative samples. A series of dilutions of each enzyme prparation was assayed quantitatively for peroxidase and catalase activity.

Peroxidase activity was determined colorimetrically by the method of Anderson *et al. (1)* using o-phenylenediamine dihydrochloride as a substrate. Catalase was determined by the titrimetric procedure of Sumner and Somers *(20)*. These data were interpreted according to the method of Laidler *(15)*.

**Effect of processing time, acidity, and storage temperature and time on off-flavor in fresh-pack dill pickles.** In the 1950 and 1951 seasons, laboratory and commercial packs of fresh whole cucumber pickles were packed in one-quart glass containers in much the same manner as described by Esselen *et al. (7)*. In the 1951 packs some of the complicating variations between samples at time of pasteurization were minimized by controlling the fill-in weights of pickles. The jars were each packed with 13 pickles weighing approximately 20 ounces. By adding 12 ounces of brine, a 5 to 3 ratio of pickle to brine was maintained. All the packs were pasteurized for the times indicated at 180° F. (82° C.).

Some of the packs were assayed quantitatively for peroxidase activity at the end of a 72-hour storage period. The packs were stored at 40° F. (4.4° C.), 70° F. (21.1° C.), and 100° F. (37.8 C.). After 6 and 18 months of storage, the samples were assayed for peroxidase activity and subjected to taste panel examination for the detection of deterioration in quality as a result of enzyme action during storage. Representative results obtained are listed in Table 1.

**Packs with added peroxidase and catalase.** Purified suspensions of cucumber peroxidase were prepared by the method of Hussein and Cruess *(9)* as modified by Nebesky *et al. (18)*. Qualitative tests for ascorbic acid oxidase, pectin methyl esterase and catalase were negative, whereas tests for polyphenol oxidase activity were positive. The latter enzyme was readily inactivated by heating to 143.6° F. (62° C.) for 10 minutes, as suggested by Keilin and Hartree *(12)*.

Horse-radish peroxidase was prepared by the method of Keilin and Hartree *(12)*. Cecil and Ogston *(4)* found that samples of peroxidase prepared in this manner contained 92% of the refracting material that formed the main sedimentary boundary in the Svedberg oil-turbine ultracentrifuge.

Catalase was crystallized from fresh dairy cattle liver by the method of Kitagawa and Sirakawa *(13)*. Recrystallization was carried out by the method of Sumner and Dounce *(19)*.

The following procedure was devised to provide more direct evidence of the relation of peroxidase activity to off-flavor development in pickles. Packs of pickles, freed from peroxidase and catalase activity by pasteurizing at 180° F. (82.2° C.) for 180 minutes, were inoculated aseptically with various concentrations of purified preparations of cucumber and horse-radish peroxidase and liver catalase. Controls were prepared by inoculating enzyme preparations that had been previously inactivated by autoclaving for 10 minutes at 240° F. (115.6° C.).

The small quantity of purified enzyme material available necessitated a procedure to permit the use of small amounts of pickle purée. Nebesky *et al. (17)* have suggested for work of this type the use of small 25-ml. vaccine-type serum bottles in which puréed material can be packed. Although the results obtained with whole pickles differed quantitatively from those with puréed packs, the general relations between enzymes and off-flavors and their influencing factors remained unaltered.

Purées were prepared by placing washed cucumbers through a conventional meat grinder. To the ground cucumbers was added a brine, 37.5% by weight, containing 5% sodium chloride and acetic acid concentrations as indicated. The suspensions were then further mixed in a Waring blender for 5 minutes. Twenty ml. of the puréed pickles were packed into the serum bottles. The bottles were sealed with serum, sleeve type, self-sealing rubber stoppers with a depressed central area for introducing a hypodermic needle. The serum bottles of pickle purée were pasteurized for 180 minutes at 180° F. (82.2° C.) to effect preservation and to destroy the peroxidase and catalase. Purified enzyme preparations were then added aseptically as indicated in Table 3.

TABLE 1

**Effect of processing time, acidity, storage temperature, and time on off-flavor in fresh pack dill pickles during storage for six months**

| Pack no. | Ingoing brine acidity | Process time | Storage condition | Transmission value [a] | | Activity loss in storage | Flavor |
|---|---|---|---|---|---|---|---|
| | | | | 72 hrs. | 6 mos. | | |
| | *percent* | *min.* | | *percent* | | *percent* | |
| 1.1 | 1.2 | 15 | 40° F. | 39.3 | 40.1 | 2 | marked off |
| | | 20 | | 48.1 | 48.3 | 2 | marked off |
| | | 25 | | 68.1 | 67.2 | 1 | acceptable |
| | | 30 | | 71.1 | 71.1 | 0 | acceptable |
| | | 35 | | 86.0 | 86.1 | 4 | acceptable |
| | | 40 | | 93.0 | 94.1 | 17 | acceptable |
| 1.2 | 1.2 | 15 | 70° F. | 38.0 | 56.0 | 40 | off |
| | | 20 | | 47.3 | 65.0 | 42 | acceptable |
| | | 25 | | 68.2 | 76.2 | 31 | acceptable |
| | | 30 | | 73.2 | 85.6 | 39 | acceptable |
| | | 35 | | 88.0 | 91.0 | 31 | acceptable |
| | | 40 | | 93.0 | 96.2 | 49 | acceptable |
| 1.3 | 1.2 | 15 | 100° F. | 33.3 | 83.1 | 83 | off |
| | | 20 | | 48.2 | 88.2 | 83 | off |
| | | 25 | | 67.2 | 91.0 | 75 | acceptable |
| | | 30 | | 74.0 | 94.2 | 80 | acceptable |
| | | 35 | | 87.1 | 96.2 | 71 | acceptable |
| | | 40 | | 90.3 | 98.2 | 81 | acceptable |
| 2.1 | 1.6 | 15 | 40° F. | 24.2 | 24.2 | 0 | marked off |
| | | 20 | | 30.3 | 31.3 | 5 | marked off |
| | | 25 | | 36.0 | 36.0 | 0 | marked off |
| | | 30 | | 56.3 | 56.3 | 0 | marked off |
| | | 35 | | 69.1 | 69.2 | 2 | acceptable |
| | | 40 | | 78.2 | 78.3 | 2 | acceptable |
| 2.2 | 1.6 | 15 | 70° F. | 28.3 | 44.1 | 35 | off |
| | | 20 | | 34.0 | 52.2 | 41 | off |
| | | 25 | | 41.2 | 59.3 | 41 | off |
| | | 30 | | 60.3 | 75.2 | 42 | acceptable |
| | | 35 | | 68.3 | 80.2 | 41 | acceptable |
| 2.3 | 1.6 | 15 | 100° F. | 28.0 | 78.2 | 81 | off |
| | | 20 | | 33.1 | 72.0 | 70 | off |
| | | 25 | | 39.3 | 89.3 | 88 | off |
| | | 30 | | 58.3 | 91.1 | 83 | acceptable |
| | | 35 | | 66.2 | 92.2 | 80 | acceptable |
| | | 40 | | 78.0 | 96.2 | 85 | acceptable |
| 5.1 | 2.0 | 15 | 40° F. | 33.3 | 34.2 | 2 | marked off |
| | | 20 | | 39.0 | 39.2 | 1 | marked off |
| | | 25 | | 43.0 | 43.0 | 0 | marked off |
| | | 30 | | 56.1 | 56.2 | 1 | marked off |
| | | 35 | | 63.2 | 64.0 | 1 | acceptable |
| | | 40 | | 85.1 | 85.3 | 4 | acceptable |
| 5.2 | 2.0 | 15 | 70° F. | 33.0 | 50.3 | 40 | off |
| | | 20 | | 38.2 | 57.1 | 41 | off |
| | | 25 | | 44.3 | 64.3 | 46 | acceptable |
| | | 30 | | 55.3 | 76.1 | 39 | acceptable |
| | | 35 | | 60.2 | 73.0 | 37 | acceptable |
| | | 40 | | 78.0 | 87.2 | 45 | acceptable |
| 5.3 | 2.0 | 15 | 100° F. | 30.3 | 81.1 | 81 | off |
| | | 20 | | 35.2 | 79.0 | 77 | off |
| | | 25 | | 42.0 | 88.3 | 86 | off |
| | | 30 | | 53.1 | 87.1 | 78 | acceptable |
| | | 35 | | 59.2 | 87.0 | 73 | acceptable |
| | | 40 | | 80.1 | 98.0 | 90 | acceptable |

[a] High readings indicate low activity; low readings indicate high activity.

After storage for 6 months, the inoculated samples of whole and puréed pickles were opened, and their quality evaluated. The results obtained are listed in Tables 2 and 3.

**Effect of acetic acid on the thermal inactivation rate of peroxidase in cucumbers.** *Puréed Packs.* Thermal inactivation data were first obtained on purées with final acidities of 0.0, 0.5, 0.9, and 1.9%. Pyrex tubes with an outside diameter of 9 mm., an inside diameter of 7 mm., and 125 mm. in length were used in the thermal inactivation determinations. Two ml. of the purée at each acid level were pipetted into a series of these tubes, which were then sealed in an oxygen flame. The destruction runs were

**TABLE 2**

**The effect of purified preparations of peroxidase, catalase-peroxidase and catalase on the development of off-flavor in pickles processed at 180° F. (82.2° C.)**

| Residual peroxidase activity | Enzyme preparation | Activity based on cucumbers | Flavor |
|---|---|---|---|
| *percent* | | *percent* | |
| 0.0 | Liver catalase | 100.0 | Stale |
| | Liver catalase | 100.0 | Stale |
| | Inactivated liver catalase | ..... | Acceptable |
| | Cucumber peroxidase | 0.3 | Trace off |
| | Cucumber peroxidase | 2.0 | Sl. off |
| | Cucumber peroxidase | 100.0 | Bitter |
| | Cucumber peroxidase | 1000.0 | Marked bitter |
| | Inactivated cucumber peroxidase | ..... | Acceptable |
| | Horse-radish peroxidase | 100.0 | Bitter |
| | Horse-radish peroxidase | 1000.0 | Marked bitter |
| | Inactivated horse-radish peroxidase | ..... | Acceptable |
| .30 | Liver catalase | 10 | Sl. off |
| .31 | Liver catalase | 10 | Sl. off |
| .39 | Liver catalase | 100.0 | Sl. off |
| .30 | Liver catalase | 100.0 | Sl. off |
| .38 | Liver catalase | 1000.0 | Sl. off |
| .34 | Liver catalase | 1000.0 | Sl. off |
| .36 | Inactivated liver catalase | ..... | Off |
| .47 | Inactivated liver catalase | ..... | Off |
| .38 | None | ..... | Off |
| .33 | None | ..... | Off |

then made at each acid level at 3 or more temperatures between 170° F. (76.7° C.) and 212° F. (100° C.), as described by Kaplan *et al. (11)*. This operation was carried out in a constant temperature oil bath, as described by Esselen and Tischer *(8)*.

Peroxidase inactivation points were determined at temperatures of 170, 180, 190, 200, and 212° F. (76.7, 82.2, 87.8, 93.0, 100° C.) on duplicate samples by the procedure described by Kaplan *et al. (11)*. The presence of peroxidase activity was determined by the qualitative test described by Anderson *et al. (1)*. Thermal inactivation data for peroxidase are shown in Table 4.

*Whole pickles.* Heat penetration data for pasteurized whole pickles were obtained from the work of Esselen *et al. (7)*. From a statistical analysis of heat penetration data on jars of pickles from 28 different packs processed at 180° F. (82.2° C.), values were calculated for the slowest and most rapid heating jars of pickles. These data were converted into destruction values.

The destruction values for peroxidase with 0.0% acid were the only values calculated and plotted. It was previously determined that at the end of a 100-minute process at 180° F. (82.2° C.) the pH of the center core of the cucumbers does not vary significantly from its natural pH of 5.2.

From the thermal destruction data obtained and heat penetration data for quart jars of whole fresh-pack pickles, Esselen *et al. (7)*, it was calculated that pasteurization for 134 to 166 minutes at 180° F. (82.2° C.) was required to inactivate the peroxidase completely in quart jars of fresh-pack pickles.

## RESULTS AND DISCUSSION

**The influence of pasteurization time, acidity, storage time and temperature on residual peroxidase activity and off-flavor development.** The peroxidase activity of fresh pickling-type cucumbers was calculated to be approximately 13% of that of young horse-radish roots. Since horse-radish is considered one of the better sources of peroxidase, the cucumber was considered to contain substantial amounts of this enzyme. The concentration of catalase found was significant, amounting to about 1% of that of fresh beef liver.

It will be noted from Table 1 that in each experimental pack there was a pasteurization level that resulted in a "satisfactory" product. This level ranged from 15 to 35 minutes at a temperature of 180° F. (82.2° C.). However, in these acceptable packs there was a definite residual level of peroxidase activity after a 6-month storage period. After pasteurization the transmission values for the peroxidase tolerated ranged from 52.2 to 68.2%, or about 0.17 to 0.28% of that originally present in fresh cucumbers.

**TABLE 3**

**The effect of purified preparations of peroxidase, catalase-peroxidase and catalase on the development of off-flavor in puréed pickles**

| Ingoing brine acidity | Enzyme added [1] | Activity based on cucumbers | Flavor Storage temperature | | |
|---|---|---|---|---|---|
| | | | 40° F. | 70° F. | 100° F. |
| *percent* | | *percent* | | | |
| 0.0 | Liver catalase | 41.0 | Stale | Sl. stale | Trace stale |
| | Liver catalase | 82.0 | Stale | Sl. stale | Trace stale |
| | Liver catalase | 123.0 | Stale | Sl. stale | Trace stale |
| | Liver catalase | 164.0 | Stale | Sl. stale | Trace stale |
| | Inact. liver catalase | ..... | Acceptable | Acceptable | Acceptable |
| | C Peroxidase | 0.27 | Sl. off | Sl. off | Sl. off |
| | C Peroxidase | 0.54 | Sl. off | Sl. off | Sl. off |
| | C Peroxidase | 0.81 | Off | Off | Off |
| | Inact. C Peroxidase | ..... | Acceptable | Acceptable | Acceptable |
| | HR Peroxidase | 0.27 | Sl. off | Sl. off | Sl. off |
| | HR Peroxidase | 0.54 | Sl. off | Sl. off | Sl. off |
| | HR Peroxidase | 0.81 | Off | Sl. off | Sl. off |
| | HR Peroxidase | 162.0 | Marked off | Off | Off |
| | Inact. HR Peroxidase | ..... | Acceptable | Acceptable | Acceptable |
| 0.8 | Liver catalase | 41.0 | Stale | Sl. stale | Acceptable |
| | Liver catalase | 82.0 | Stale | Sl. stale | Acceptable |
| | Liver catalase | 123.0 | Stale | Sl. stale | Acceptable |
| | Inact. liver catalase | ..... | Acceptable | Acceptable | Acceptable |
| | C Peroxidase | 0.27 | Sl. off | Sl. off | Trace off |
| | C Peroxidase | 0.54 | Sl. off | Sl. off | Trace off |
| | C Peroxidase | 0.81 | Off | Sl. off | Trace off |
| | Inact. C Peroxidase | ..... | Acceptable | Acceptable | Acceptable |
| | HR Peroxidase | 0.27 | Sl. off | Sl. off | Trace off |
| | HR Peroxidase | 0.54 | Sl. off | Sl. off | Trace off |
| | HR Peroxidase | 0.81 | Sl. off | Sl. off | Trace off |
| | HR Peroxidase | 162.0 | Marked off | Off | Off |
| | Inact. HR Peroxidase | ..... | Acceptable | Acceptable | Acceptable |
| | ..... | ..... | Marked off | Off | Off |
| | Liver catalase | 82 | Off | Sl. off | Sl. off |
| | Inact. liver catalase | ..... | Marked off | Off | Off |
| 1.6 | Liver catalase | 41 | Stale | Sl. stale | Acceptable |
| | Liver catalase | 82 | Stale | Sl. stale | Acceptable |
| | Liver catalase | 123 | Stale | Sl. stale | Acceptable |
| | Inact. liver catalase | ..... | Acceptable | Acceptable | Acceptable |
| | C Peroxidase | 0.27 | Sl. off | Sl. off | Sl. off |
| | C Peroxidase | 0.54 | Sl. off | Sl. off | Sl. off |
| | C Peroxidase | 0.81 | Off | Sl. off | Sl. off |
| | Inact. C Peroxidase | ..... | Acceptable | Acceptable | Acceptable |
| | HR Peroxidase | 0.27 | Sl. off | Sl. off | Sl. off |
| | HR Peroxidase | 0.54 | Sl. off | Sl. off | Sl. off |
| | HR Peroxidase | 0.81 | Off | Sl. off | Sl. off |
| | HR Peroxidase | 162.0 | Marked off | Off | Off |
| | Inact. HR Peroxidase | ..... | Acceptable | Acceptable | Acceptable |
| | ..... | ..... | Marked off | Off | Sl. off |
| | Liver catalase | 82 | Off | Sl. off | Trace off |
| | Inact. liver catalase | ..... | Marked off | Off | Sl. off |
| 3.0 | Liver catalase | 41.0 | Acceptable | Acceptable | Acceptable |
| | Liver catalase | 82.0 | Acceptable | Acceptable | Acceptable |
| | Liver catalase | 123.0 | Acceptable | Acceptable | Acceptable |
| | Inact. liver catalase | ..... | Acceptable | Acceptable | Acceptable |
| | C Peroxidase | 0.27 | Sl. off | Sl. off | Sl. off |
| | C Peroxidase | 0.54 | Sl. off | Sl. off | Sl. off |
| | C Peroxidase | 0.81 | Sl. off | Sl. off | Sl. off |
| | Inact. C Peroxidase | ..... | Acceptable | Acceptable | Acceptable |
| | HR Peroxidase | 0.27 | Sl. off | Sl. off | Sl. off |
| | HR Peroxidase | 0.54 | Sl. off | Sl. off | Sl. off |
| | HR Peroxidase | 0.81 | Sl. off | Sl. off | Sl. off |
| | HR Peroxidase | 162.0 | Off | Off | Off |
| | Inact. HR Peroxidase | ..... | Acceptable | Acceptable | Acceptable |
| | ..... | ..... | Marked off | Off | Off |
| | Liver catalase | 82.0 | Marked off | Off | Off |
| | Inact. liver catalase | ..... | Marked off | Off | Off |

[1] The abbreviations Inact., C, and HR refer to *inactivated, cucumber,* and *horse-radish,* respectively.

**TABLE 4**

**Thermal resistance of the peroxidase cucumbers at various acid levels**

| Cut-out acidity | 170° F. (76.7° C.) | | 180° F. (82.2° C.) | | 190° F. (87.8° C.) | | 200° F. (93.3° C.) | | 212° F. (100° C.) | | z[a] Value | $F^{b}_{180}$ | $F^{b}_{200}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Percent* | *Surv.* | *Dest.* | *Surv.* | *Dest.* | *Surv.* | *Dest.* | *Surv.* | *Dest.* | *Surv.* | *Dest.* | | | |
| 0.0 | .... | .... | 120 | 130 | 28 | 30 | 7.5 | 8.0 | 1.5 | 1.75 | 16.6 | 125.00 | 7.90 |
| 0.5 | .... | .... | 19 | 21 | 4.5 | 5.0 | 1.0 | 1.25 | .... | 0.25 | 16.0 | 21.00 | 1.18 |
| 1.0 | 60 | 64 | 10 | 11 | 1.75 | 2.00 | 0.25 | 0.5 | .... | .... | 13.3 | 10.80 | 0.35 |
| 1.9 | 34 | 36 | 3.5 | 4.0 | 0.25 | 0.5 | .... | .... | .... | .... | 10.3 | 3.75 | 0.04 |

[a] z = slope of thermal destruction curve.
[b] $F_{180}$ and $F_{200}$ = time in minutes required to destroy enzyme at 180 and 200° F., respectively.

There was no apparent relationship between the acidity of the ingoing brine and the pasteurization time necessary to prevent off-flavors from enzyme action.

A measurable loss in peroxidase activity occurred during storage. Thus, by the sixth month of storage at room temperature, approximately 40% of the peroxidase present shortly after pasteurization had been destroyed. There was no significant difference in intensity of off-flavor with storage time for 6 months as compared to 18 months at any of the pasteurization levels. However, the packs stored for 18 months were somewhat softer in texture than those tested at 6 months.

The peroxidase activity of the samples and the intensity of off-flavor at all pasteurization levels was considerably greater at low than at high storage temperatures. The loss of residual enzyme activity during a 6-month storage period at temperatures of 40° F. (4.4° C.), 70° F. (21.1° C.), and 100° F. (37.8° C.) was 1, 40, and 83%, respectively. This relationship is probably due to the balance between acceleration of peroxidase activity as a result of increased storage temperature and the increased inactivation of the enzyme itself as a result of this higher temperature: that is, the increased activity cannot counterbalance increased enzyme decomposition.

Incidental effects of storage temperature included: (a) complete curing of the pickle packs stored at 70° F. (21.1° C.) and 100° F. (37.8° C.), (b) little if any curing at 40° F. (4.4° C.), (c) no curing of packs processed at 212° F. (100° C.) for 120 minutes and held in cold storage for 6 months.

**The effect of purified enzyme suspensions of peroxidase and catalase on the development of off-flavor in whole and puréed pickles.** Results in Tables 2 and 3 indicate that the degree of off-flavor is proportional to the peroxidase concentration. A bitter after-taste was very evident at the higher peroxidase concentrations. It was also noted that horse-radish peroxidase preparations caused off-flavors indistinguishable from those of cucumber peroxidase.

Of further interest was the fact that catalase diminished the intensity of the characteristic off-flavors caused by peroxidase activity. It would appear that the formation of so-called peroxidative-type off-flavors was inhibited by catalase.

Catalase itself produced an off-flavor, which could only be characterized as stale or flat. This supports the conclusion of Chance *(5)*, Krause *(14)*, Keilin and Hartree *(12)*, and Tauber *(21)* that catalases are a special group of peroxidases and that *in vivo* there are many other compounds affected by catalase.

Results obtained with whole and puréed pickles were similar, the primary difference being that bitterness was not noted in the puréed at the higher peroxidase concentrations as was the case with whole pickles. In addition, the samples of purées stored at 100° F. (37.8° C.) showed a definite cooked odor and flavor attributable to warm storage conditions, whereas this flavor and odor could not be detected in whole pickles stored at the same temperature. The cooked odor and flavor increased with increasing acidity.

Of interest also were the color changes that were noted in the puréed packs during pasteurization at 180° F. (82.2° C.) After a few minutes of heating an olive color developed in purées containing 0.8, 1.6, and 3.0% acetic acid. The rate of development of this color increased with increasing acidity. The olive color persisted for about 20 minutes of heating at which time the characteristic green color originally present in the purée returned. Further heating caused little visible change in color.

In cold storage, samples that had been removed early in the pasteurization process maintained their olive color. In certain instances the olive color faded to an even greater extent. Jorgenson and Kidd *(10)* have also noted that in acid solutions chlorophyll turns yellow and then bleaches. Comparative samples stored at 70° F. (21.1° C.) or at 100° F. (37.8° C.) soon developed a green color similar to that originally present. This tendency increased with increasing acidity.

Purées pasteurized without the addition of acid showed no significant color changes during heating or storage.

Reference to enzymatic activity apparently will not explain this color deterioration. Pasteurization for a period sufficient to inactivate peroxidase failed to prevent changes in color.

The formation of the olive-green color from the green has been described by Campbell *(3)*, who demonstrated that the magnesium from chlorophyll is replaced by hydrogen to produce the yellowish product pheophytin. This reaction has been found to occur *in vivo* in improperly stored frozen peas in which the localized acids of the sap caused a color change. Evidence that these acids were responsible for the color change lies in the fact that scalded peas stored at the same temperature in airtight containers over ammonia do not discolor, the acids of the tissues presumably being neutralized by the ammonia absorbed.

It has been demonstrated that the green in chlorophyll is dependent on the presence of magnesium in its molecule. Jorgenson and Kidd *(10)* have shown that magnesium is readily split from the chlorophyll molecule *in vitro* by weak solutions of acetic, boric, oxalic, and carbonic acids.

The reappearance of the green color was attributed to the acid hydrolysis of pheophytin. Lingelsheim *(16)* has suggested that the acid subsequently hydrolyzes pheophytin releasing the phytyl group and giving rise to free carboxylic pheophorbide. He found that the final green coloring matter of chlorophyll breakdown was soluble in chloroform but, unlike chlorophyll, insoluble in benzene. This property was observed in the present investigation. It will be noted from this discussion that decreasing temperatures tend to slow down the reappearance of the green color. This fact is in agreement with Lingelsheim's proposal *(16)*.

From the data obtained it is concluded that although the odor changes paralleled the color changes somewhat these two reactions were not necessarily related. Diehl, Campbell and Berry *(6)* came to no definite conclusions in regard to the developement of a yellow color in scalded peas stored at 15° to 20° F. (—9.4° to —6.7° C.), although they suggested that off-odors and color changes were not necessarily related. This change is also known to occur in frozen spinach and green beans.

To inactivate the peroxidase of pickles completely it was calculated that pasteurization for 134 to 166 minutes at 180° F. (82.2° C.) was required. Although no experimental packs were prepared to substantiate these results, it was established in other phases of the investigation that peroxidase was not destroyed by 120-minutes at 180° F. (82.2° C.) but was inactivated by a pasteurization time of 180 minutes at this same temperature. The derived inactivation values aptly demonstrate the futility of using a negative peroxidase test as a criterion for the pasteurization of such acid foods. However, a practical control test might be devised to determine whether or not the residual peroxidase activity was sufficient to result in the development of off-flavor during storage. This could be accomplished by changing the pH of the buffer used, thereby decreasing the sensitivity of the test.

## SUMMARY AND CONCLUSIONS

Peroxidase activity in fresh-pack pickles is associated with the development of off-flavor and off-odor during storage. High degrees of peroxidase activity intensify the development of bitter flavors in this product.

The development of such off-flavors in pickles containing active peroxidase is markedly increased during storage at 40° F. (4.4° C.) as compared with storage at 70° F. (21.1° C.) or 100° F. (37.8° C.). Enzyme inactivation at the higher storage temperatures is probably responsible for this rather unorthodox situation.

Off-flavors were prevented by a pasteurization treatment which sufficiently reduced the peroxidase activity to a low level. Pasteurization of quart jars of whole fresh-pack pickles for 35 minutes at 180° F. (82.2° C.) has been adequate to prevent such off-flavors. The pasteurization level was not dependent on acidity, and factors previously indicated by Esselen *et al. (7)* are of greater importance.

Purified preparations of cucumber and horse-radish peroxidase caused the development of off-flavors indistinguishable from those found in under-pasteurized pickle packs. Purified beef liver catalase decreased the intensity of the off-flavor associated with peroxidase activity but in itself resulted in the development of a definite characteristic off-odor.

Color changes from green to yellow to green during heating of puréed pickle packs were considered to be the result of acid hydrolysis of chlorophyll, the latter compound being hydrolyzed to the yellowish product pheophytin with the acid subsequently hydrolyzing pheophytin to produce green-colored end products. No relation was found between these color changes and enzyme activity.

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# Recommendations on Procedures for Determining Grades of Raw, Canned, and Frozen Lima Beans[a,b]

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**Procedures for determining grades of raw canned, and frozen lima beans are described. A means of obtaining more representative samples of the raw product is proposed and improved methods for determining the percent of trash, defects, and maturity scores are presented. Quality of the canned and of the frozen product is discussed in terms of objective and subjective tests.**

Existing procedures for determining the grades of lima beans whether developed by processors, or official State or Federal agencies, have long been considered inadequate. With the advent of the green-seeded varieties which do not turn white upon maturation, these grades have become entirely unsuitable.

Present methods used for obtaining a sample for grading vary, but are generally haphazard and include a large margin of error. A common practice in the sampling of raw lima beans is to use a 4-oz. subsample from a 3-pound sample of a load of lima beans which may weigh 400 to 1000 pounds. When 20 replicate samplings were made of one lot of lima beans, the "percent whites" was found to average $12.1 \pm 3.7$. Thus, in about one out of 3 cases a single sampling obtained in the usual manner could have resulted in a "percent whites" value of less than 8.4 or higher than 15.8.

Deductions for trash in the raw lima beans are usually handled in an arbitrary fashion. It is common practice to make a uniform deduction from the total weight, not taking into account substantial differences in trash content resulting from different methods of digging and vining.

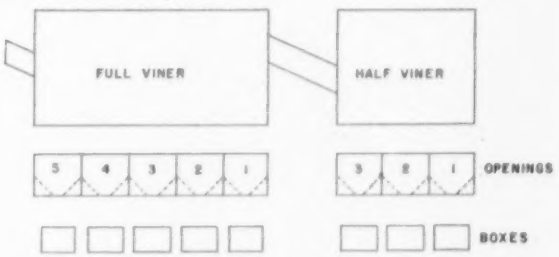
Actual procedures used for determining the grades vary considerably, but in general scores are assigned on the basis of the presence of white or shrivelled, and defective beans. It has been demonstrated *(4)* that "percent white beans" is not necessarily closely correlated with maturity. Where there is a uniform pod set, a substantial number of white beans which may have just turned color but have not begun to shrivel, will result in a sample not as mature as the "percent whites" would indicate; where the raw material is variable, perhaps because of a small early first set, the average maturity score would be poorer than the small percentage of white beans would indicate. "Percent white beans" is of course entirely inapplicable to the measurement of maturity of green-seeded varieties which do not turn white upon maturation. With these green-seeded beans the advanced state of maturity can be detected visually only after a substantial amount of shrivelling has taken place.

Because of this situation there is little incentive for the grower to strive to supply the processor with raw lima beans which when processed would result in a high quality pack. Therefore, this work was undertaken in order to develop a reasonable, accurate, and practical procedure which may lead to these consequences:

a. The grower can sell top quality for top prices.
b. The processor can purchase raw material of known quality for a fair price.
c. The buyer can purchase a finished product of known quality.

## MATERIALS AND METHOD

Lima beans are shelled ordinarily by a single or double viner (Figure 1). Where a single viner is employed, the shelled beans drop into an elongated hopper divided into 5 compartments or openings (1, openings 1 to 5). Where a double viner is used, the vines are first fed into a shorter "half viner" where the beans are collected in a shorter hopper divided into 3 compartments (1, openings 1 to 3). The beans collected in all these openings are generally transferred into lug boxes, although in some installations they drop onto a belt and are removed continuously into suitable containers.




SCHEMATIC DIAGRAM
OF A TANDEM VINER

**Figure 1. Schematic diagram of a viner, showing the elongated hopper divided into openings, with lug boxes placed under each opening.**

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[b] Presented at the Thirteenth Annual Meeting of the IFT, Boston, Massachusetts, June 22, 1953.

[c] With the technical assistance of Paul Beach and Earl Giggard, John H. Dulany & Son; Hatton P. Rogers, Jr., Phillips Packing Company, George Steinmetz and Richard Harris, H. P. Cannon & Son; E. L. Morin, Seabrook Farms; Wm. Charles, Wm. Hudson, and George Kierstead, Production and Marketing Administration; Charles Dame and Arron Kornetsky, University of Maryland.

**Obtaining the sample.** A common sampling procedure is for the inspector to remove a scoop of beans from each opening of the viners, combine this material, and remove a 4-oz. subsample for inspection. Since the more mature lima beans generally drop out in the first viner openings and since the bulk of the lima beans drop through these same openings, it was thought that this system of removing equal portions from each viner opening would tend to give too much weight to the relatively few immature beans that come out of the last viner opening. Hence during the 1951 season a thorough study of viner performance was undertaken; samples were taken from each viner opening as well as composite samples prepared as follows (Figure 1):

A. Equal portion from each opening, double viner
B. Equal portion from each opening, long viner only
C. Equal portion from each box, double viner
D. Equal portion from each box, long viner only

The entire load from which these samples were drawn was weighed and then passed through a clipper cleaner fitted with 40″/64″, and 24″/64″ screens; leaves, stems, pods, etc. remained on the large screen and small particles of trash, largely soil and small plant particles, passed through the lower small screen. The material remaining on the small screen was then weighed again, and the difference from the original weight considered as trash.

Individual samples obtained from each viner opening and the composite samples were all graded by an official State-Federal inspector, and where possible, by a plant inspector as well. Determinations of maturity were made with a shear-press in accordance with the procedure described by Kramer *et al. (3)*. The remaining material was blanched, frozen, and canned in accordance with standard processing practices.

In order to obtain a wide range of maturity, other loads were separated by bean size and brine flotation. U. S. grades, shear-press values, and canned and frozen samples were also obtained from this material.

During the 1952 season, a similar procedure was followed, except that the new model of the shear-press was used (Figure 2). When available, as many as 3 individual shear-presses were operated side by side in order to study variability among individual machines. In addition a sample cleaning box (Figure 3) was used—a box of 2-feet cube containing the 40″/64″ and 24″/64″ screens, and a sample collection box (Figure 4) consisting of a standard lug box equipped with a pyramidal lid having an opening (4″ x 4″) at the top. When placed on a viner, a 10- to 20-pound sample would be collected continuously from a load of vines as the beans were vined.

The frozen and canned samples were analyzed for color by the use of the Hunter color difference meter *(2)* and for alcohol insoluble solids (A.I.S.) *(1)*. A duplicate set of samples was submitted to a taste testing panel consisting of 14 food technologists.

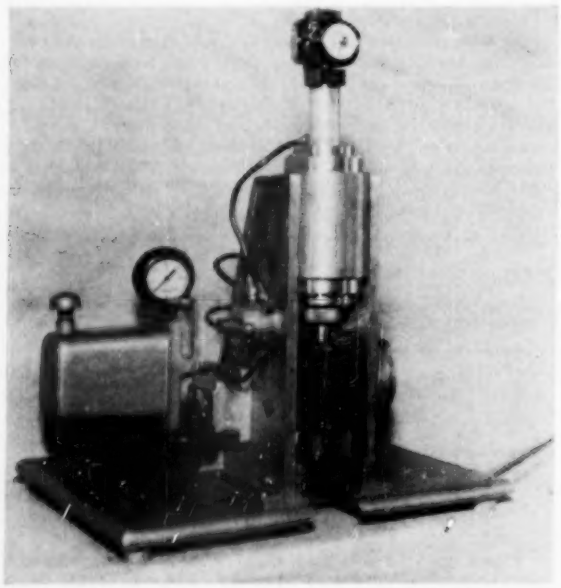

**Figure 2. The new model of the shear-press.**

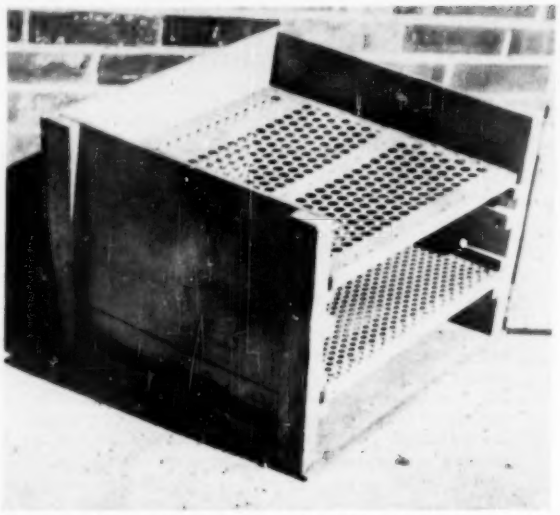

**Figure 3. Sample cleaning box used to determine percent trash.**

**Figure 4. Sample collection box, by which a continuous sample may be obtained while the beans are being vined.**

## RESULTS AND DISCUSSION

**Raw lima beans.** *Sampling.* The average performance of a double viner is presented in Table 1, and of a single viner in Table 2. Data on the percentage of the beans dropping through the different openings demonstrate clearly the commonly observed phenomenon that ordinarily most of the beans drop into the first 2 or 3 openings of the full viner; smaller quantities drop into the last 2 openings of the full viner. Hence, if the sample is obtained by taking equal quantities from each opening, the effect of the more tender beans in the last 2 openings is overemphasized. In fact, the data obtained from the 4 methods of collecting composite samples indicate that there is a small, but significant difference in

**TABLE 1**

**Average performance of a double viner**

| Opening | % of total weight | | | % loss after cleaning | | | Analyses raw limas | |
|---|---|---|---|---|---|---|---|---|
| | Ave. | Min. | Max. | Ave. | Min. | Max. | Shear-Press | U. S. Grade % No. 1 equivalent |
| Half Viner | | | | | | | | |
| 1st opening | 4.8 | 2.3 | 7.5 | 19.2 | 3.3 | 33.3 | 1680 | 38 |
| 2nd opening | 5.6 | 2.3 | 11.1 | 11.8 | 5.3 | 21.0 | 1630 | 40 |
| 3rd opening | 3.9 | 2.3 | 5.1 | 7.5 | 0.0 | 20.0 | 1520 | 54 |
| Full Viner | | | | | | | | |
| 1st opening | 22.3 | 19.5 | 28.0 | 8.1 | 2.9 | 16.5 | 1270 | 74 |
| 2nd opening | 22.2 | 19.1 | 26.4 | 4.6 | 2.3 | 12.5 | 1236 | 80 |
| 3rd opening | 18.3 | 13.9 | 22.1 | 5.6 | 1.9 | 15.0 | 1184 | 83 |
| 4th opening | 13.4 | 8.5 | 16.0 | 6.2 | 1.3 | 15.0 | 1174 | 84 |
| 5th opening | 9.4 | 5.3 | 8.1 | 6.7 | 2.5 | 15.0 | 1118 | 86 |
| Weighed ave. Total 100 | | | | 7.19 | 2.37 | 16.90 | 1268 | 75 |
| Weighed ave. ½ viner | 14.3 | 6.9 | 23.7 | 13.11 | 3.18 | 24.86 | 1616 | 43 |
| Weighed ave. Full viner | 85.6 | 66.3 | 100.6 | 6.21 | 2.24 | 14.74 | 1212 | 80 |

**TABLE 2**

**Average performance of a single viner**

| Opening | % of total weight | | | % loss after cleaning | | | Analyses raw limas | |
|---|---|---|---|---|---|---|---|---|
| | Ave. | Min. | Max. | Ave. | Min. | Max. | Shear-Press | U. S. Grade % No. 1 equivalent |
| 1st | 20.6 | 18.0 | 23.0 | 12.8 | 6.8 | 20.0 | 1270 | 80 |
| 2nd | 25.1 | 21.7 | 28.0 | 6.6 | 2.8 | 17.3 | 1268 | 80 |
| 3rd | 23.1 | 20.1 | 24.5 | 4.5 | 2.0 | 8.4 | 1212 | 80 |
| 4th | 17.6 | 16.0 | 19.0 | 3.9 | 1.3 | 5.7 | 1196 | 81 |
| 5th | 13.6 | 10.0 | 17.1 | 5.7 | 2.4 | 12.7 | 1168 | 84 |
| Ave. | 100.0 | ..... | ..... | 6.79 | 3.12 | 13.13 | 1222 | 81 |

the results as reported in Table 3; hence, an equal portion should be removed from each box rather than from each opening in order to obtain a representative sample.

A closer analysis of the data, however, reveals the additional fact that the average quality of a load of lima beans is practically identical with the quality of lima beans dropping into the first opening of the second viner in a double viner set-up (compare shear-press values for composite with values of individual viner openings, Table 1). Similarly, in the case of a single viner, beans emerging between the second and third viner opening are practically identical with the composite value for the whole load (Table 2). It was reasoned, therefore, that a continuous sample collected at those spots should provide a convenient method of obtaining a representative sample for the entire load.

During the 1952 season, a sampling box was constructed, consisting of a conventional lug box cut down to half height, equipped with a pyramidal galvanized, iron lid in which an opening (4″ x 4″) was cut (Figure 4). Twenty loads were then sampled with this box; at the same time equal portions were taken out of each box in each load. The average shear-press values as obtained by these 2 methods were identical (1384) and the correlation of .993 established the fact that these 2 sampling methods yielded practically identical results. For the U. S. grades also, the 2 sampling methods yielded practically identical results (92.9 vs. 93.0, r = .970).

**TABLE 3**

**Grades of raw lima beans on samples obtained by different sampling methods**

| | U. S. grade % No. 1 equivalent (ave. of 8) | Shear-press values (ave. of 4) |
|---|---|---|
| Double viner: | | |
| Equal portion from each opening | 73.1 | 1361 |
| Equal portion from each box | 73.8 | 1370 |
| Single viner: | | |
| Equal portion from each opening | 83.5 | 1274 |
| Equal portion from each box | 82.5 | 1292 |
| L.S.D. | N.S. | 10 |

It may therefore be concluded that a continuous sample obtained midway between the second and third opening of a single viner, and from the middle of the first opening of the long viner in a double-viner-set-up will provide a representative sample upon which a grade may be based. In those circumstances where a continuous unattended sample cannot be collected, the sample should consist of equal portions from each box rather than from each opening of the viner.

**Trash determination.** It is common practice to make a standard trash deduction from the total weight of each load, although it is well known that the trash content will vary considerably from load to load, and certainly from viner to viner. Weather conditions, incidence of weeds, care taken in the digging of the vines, presence or absence of a cleaning reel, the use of double or single viners, all have an effect on the amount of trash collected. Data on "percent loss after cleaning" in Tables 1 and 2 demonstrate the tremendous difference in percent trash that exists in actual viner operation. Thus in order to encourage the grower and viner operator to bring in clean beans, the trash content should be determined for each load.

During the 1952 season, a cleaning box was devised, consisting of a 2-foot cube wooden frame in which were

inserted 40″/64″ and 24″/64″ screens (Figure 3. The samples obtained by the 2 methods described above were put through this cleaner, and the percent trash noted. Here it was found that as the amount of trash increases, the percent of trash obtained from the continuous sample tended to be smaller than the percent of trash obtained from a sample consisting of equal portions from each lug box. However, a good correlation (.89) was obtained between the trash percentages obtained from the 2 sampling methods, and hence if it is desirable to obtain a trash deduction figure from a continuous sample, conversion Table 4 may be used:

TABLE 4

**Relation of trash percent obtained from continuous sample to actual percent trash in the load. (log $P_L$ = .251 + .0923 $P_c$, where $P_L$ = % trash in load, and $P_c$ = % trash in continuous sample)**

| Continuous sample | Actual |
|---|---|
| 3 | 3 |
| 4 | 4 |
| 5 | 5.1 |
| 6 | 6.4 |
| 7 | 8.0 |
| 8 | 9.8 |
| 9 | 12.0 |
| 10 | 15.0 |
| 11 | 19.0 |
| 12 | 25.0 |

**Determination of maturity.** It is generally agreed that quality of lima beans as well as other vegetables consumed in the immature "green" state is largely determined by their stage of maturity. Thus, the younger the beans, the higher the quality. Kramer and Smith *(4)* describe in detail the growth and maturation of the lima bean, pointing out that size may serve as a measure of maturity only where the entire load of lima beans is at a stage of maturity when no appreciable percentage has passed the maximum size stage and begun to shrivel. It has also been demonstrated previously that percent of white or shrivelled beans is not highly correlated with maturity as measured by taste testing panels (Figure 5). On the other hand, shear-press values showed very satisfactory correlations with maturity scores (Figure 6) and with A.I.S. content of the canned and frozen samples (Figure 7).

Raw product grades now used in the Tri-State area, are based largely on percent of white and shrivelled beans. As shown in Figure 8, these grades are fairly satisfactory for white-seeded varieties but are entirely inadequate for green-seeded varieties where the telltale white color does not appear. Furthermore, the error between 2 shear-press instruments is much smaller (1.7%) than that between 2 U. S. grade inspections (4.2%). This difference in precision is demonstrated graphically in Figure 9.

It was therefore concluded that for a measure of maturity, the shear-press is the more suitable method. There yet remained the problem of converting shear-press values to U. S. grades. This was done by reference to Figure 6 where shear-press values are plotted against panel scores. Table 5 was therefore constructed so that maturity socres for the raw lima beans, as determined by the use of the shear-press, could be used for predicting the quality of the processed product. Data in

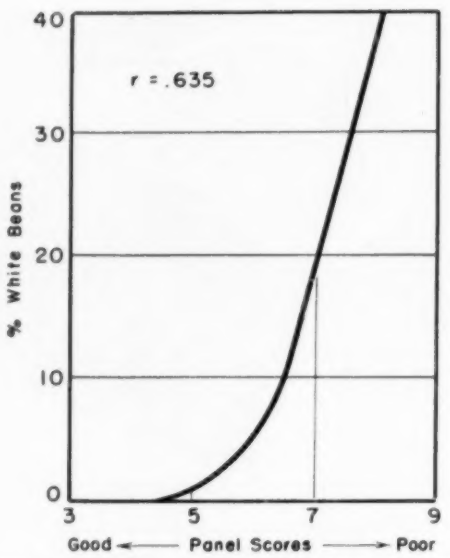


**Figure 5. Relation of "percent whites" to panel scores for maturity.**

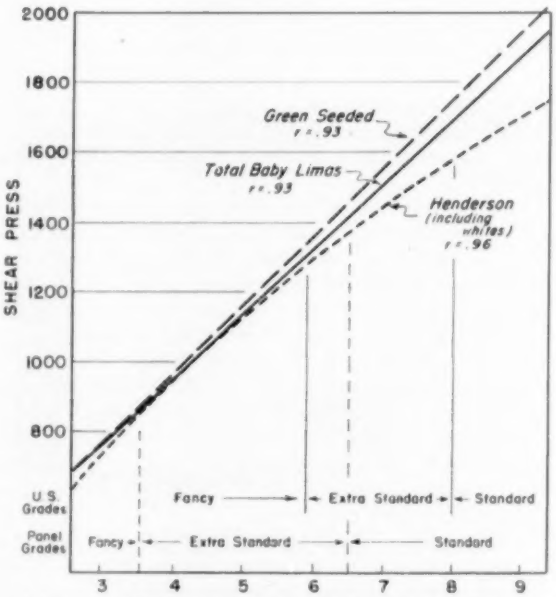


**Figure 6. Relation of shear-press values to maturity scores as obtained by a panel of food technologists, and U. S., P. M. A. graders.**

TABLE 5

**Maturity scores based on shear-press values**

| Fancy | | Extra standard | | Standard | |
|---|---|---|---|---|---|
| S-p | Score | S-p | Score | S-p | Score |
| 950 | 100 | 1400 | 91 | 1800 | 83 |
| 1000 | 99 | 1450 | 90 | 1850 | 82 |
| 1050 | 98 | 1500 | 89 | 1900 | 83 |
| 1100 | 97 | 1550 | 83 | 1950 | 80 |
| 1150 | 96 | 1600 | 87 | 2000 | 79 |
| 1200 | 95 | 1650 | 86 | 2050 | 78 |
| 1250 | 94 | 1700 | 85 | 2100 | 77 |
| 1350 | 92 | 1750 | 84 | 2150 | 76 |

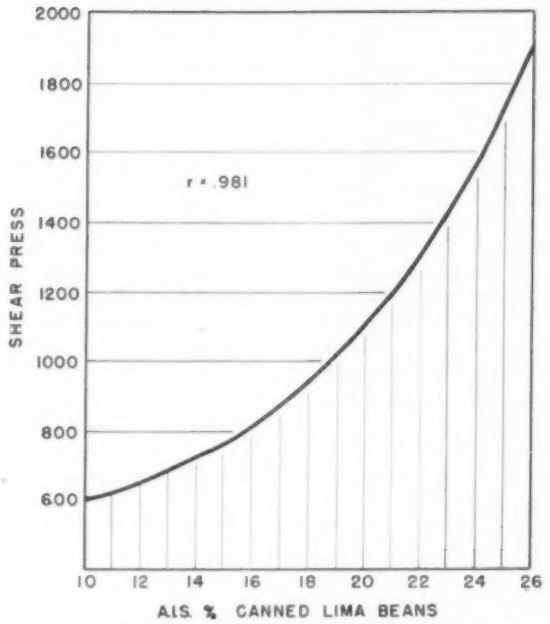


Figure 7. Relation of shear-press values on raw lima beans to percent alcohol insoluble solids of canned lima beans.

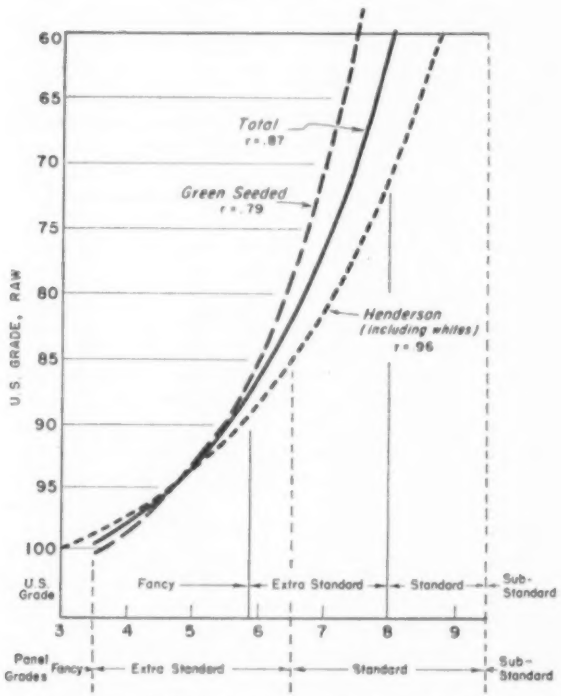


Figure 8. Relation of U. S. grades of raw lima beans to maturity scores as obtained by a panel of food technologists and U. S., P. M. A. graders.

Table 6, obtained from the regression of shear-press values on U. S. grades (see Figures 10, 11), reflect the inequality in the present grading systems, where green-seeded varieties are scored more leniently for the maturity factor than varieties which turn white upon

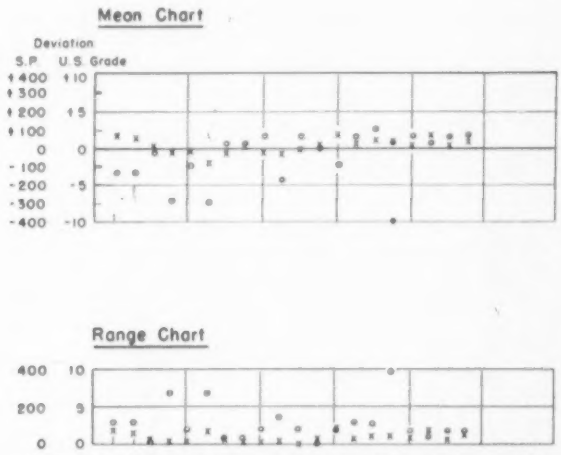


Figure 9. Mean and range charts showing relative precision of shear-press compared to U. S. graders. O (mean) line in each case is equivalent to one shear-press or one grader's score. The x denotes the deviation of the second shear-press from the 1st and the o denotes the deviation of the second U. S. grader from the first. The limits were established at one standard deviation, calculated for all the samples used.

maturation. Data in Table 6 may be used to convert the present grade to the proposed system.

**Defects.** Although present grading systems do not measure the maturity factor as precisely as does the shear-press, they do include the factor of "defects" while shear-press values provide no information on this factor. In fact white and shrivelled beans could be included with other defective beans such as discolored, broken, diseased beans, etc. Since such beans must be culled out of a high quality product, it is important for a complete grade to include information on the quantity of such cull material in the lot. It is therefore recommended that in the proposed procedure a determination

TABLE 6

Relation of present grades to proposed grades to serve as a tentative basis for new contracts

| If present grade is: | Proposed grades will average | |
|---|---|---|
| | green seeded | Henderson |
| 99 | 90 | 96 |
| 98 | 86 | 93 |
| 97 | 83 | 91 |
| 96 | 80 | 89 |
| 95 | 78 | 87 |
| 94 | 75 | 86 |
| 93 | 73 | 84 |
| 92 | 71 | 83 |
| 91 | 69 | 82 |
| 90 | 67 | 80 |
| 89 | 65 | 79 |
| 88 | 63 | 78 |
| 87 | 61 | 77 |
| 86 | 59 | 75 |
| 85 | 58 | 75 |
| 84 | 56 | 75 |
| 83 | 54 | 72 |
| 82 | 52 | 71 |
| 81 | 51 | 70 |
| 80 | 50 | 69 |

Example: Proposed grade score = 80 (green seeded beans) present grade equivalent = 96. New contract should provide payment equal to old contract payment for 96 score beans.

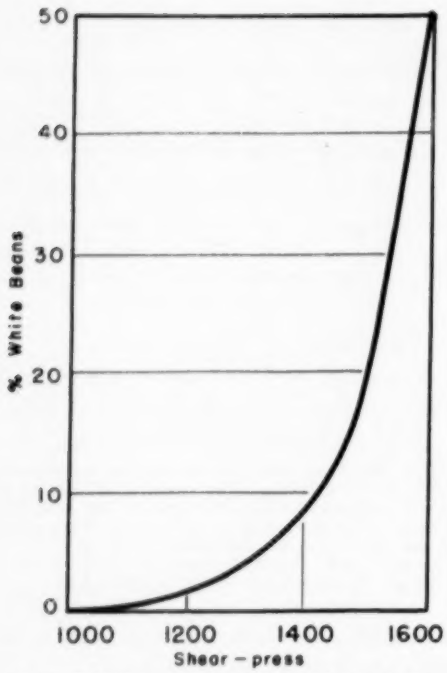


**Figure 10. Relation of "percent white" beans to shear-press values.**

be included for defects consisting essentially of the present grade with white and shrivelled beans included as culls.

**Summary of Recommended Procedures for Grading Raw Lima Beans**

1. Obtain a 10 to 20 lb. sample of vined beans by the continuous sampling method or by removing an equal portion from each box.
2. Pass through cleaning box and determine percent trash.
3. Determine percent defects including white, shrivelled, diseased or discolored beans, on a one-pound subsample.
4. Determine shear-press value in triplicate.
5. Calculate score as follows:
   Obtain maturity score from Table 5
   Subtract percent culls from maturity score
   Maturity score minus % defects = Grade

EXAMPLE:

| | |
|---|---|
| Weight of vined beans | 500 lbs. |
| Trash—10% | 50 lbs. |
| Weight of beans | 450 lbs. |
| Shear-press value—1380 | 92* |
| % defect—4 | —4 |
| Grade | 88 |

Hence, payment will be made for 450 pounds of lima beans having a grade of 88.

**Sampling of processed lima beans.** The problem of sampling of the processed product is not as difficult as that of sampling the raw. Depending on the precision desired, the number of cans or cartons removed for inspection from any given lot will depend on the variability of the units in the lot and on the size of the lot. Since quantitative data are obtained in these inspections, and the tests are destructive, a variables sampling plan is required. Sampling procedures and tables for inspection by variables may be found in the Bureau of Ordnance, Department of the Navy, Publication NAVORD OSTD 80 *(5)*.

**Canned lima beans.** In contrast to the situation with raw lima beans, the official grades for canned lima beans provide separate scores for the factors of defects and maturity *(6)*. The problem here is that no method other than human judgment is used in the evaluation of the maturity factor, although a satisfactory method is available which is now used officially for measuring the maturity of canned peas and sweet corn. This is, of course, the alcohol insoluble solids (A.I.S.) test *(1)*. It has been demonstrated *(4)* that as the maturity of canned lima beans increases, A.I.S. percent increases proportionately. This relation of A.I.S. to maturity scores provided by a panel of food technologists, including official graders, is shown in Figure 12. The correlation of .92 indicates that the A.I.S. test reflects human maturity evaluation with satisfactory accuracy. Furthermore, shear-press values on the raw lima beans are almost perfectly correlated with A.I.S. values (Figure 7) on the canned product, thus providing the processor with the opportunity of predicting the quality of the canned product with excellent accuracy from a knowledge of the maturity of the raw product. Table 7 shows how A.I.S. may be interpreted in terms of U. S. grades, where 50 is the top maturity score.

The use of A.I.S. for canned lima beans has been questioned on the grounds that dry lima beans may be soaked before canning and the A.I.S. percent may there-

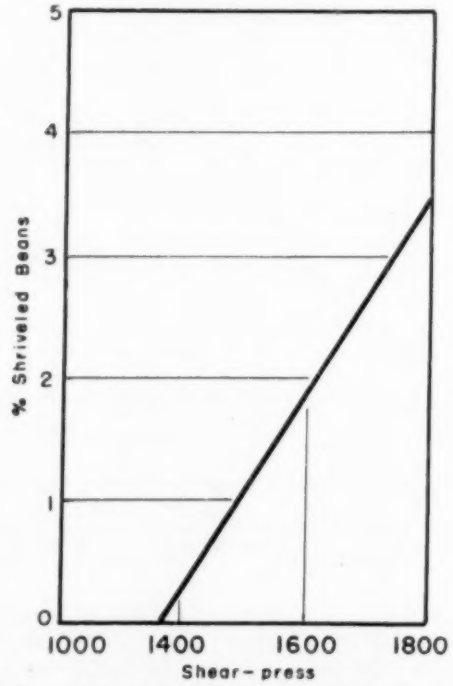


**Figure 11. Relation of percent "shrivelled beans" to shear-press values.**

*Maturity score (Table 5).

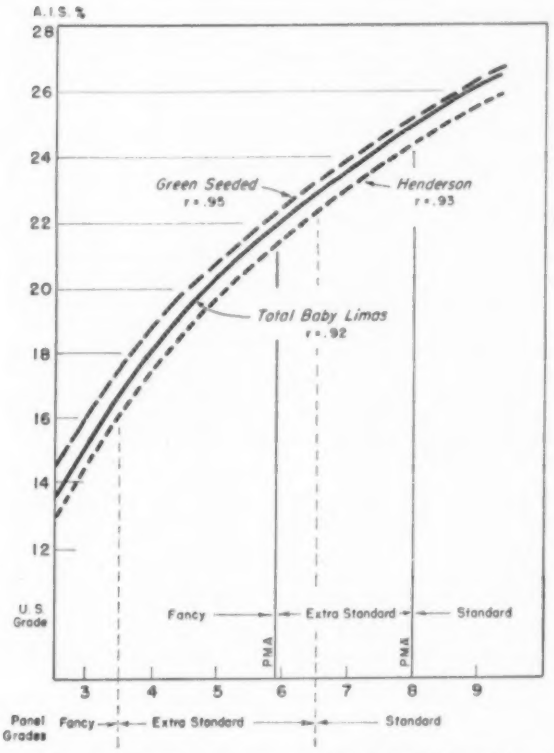


**Figure 12. Relation of percent alcohol insoluble solids of canned lima beans to maturity scores as obtained by a panel of food technologists and U. S., P. M. A., graders.**

by be lowered to values similar to mature lima beans processed fresh from the field. Because of this, a dividing line between substandard and standard lima beans cannot be established, although there is no difficulty in dividing standard maturity from higher maturity categories by the use of the A.I.S. test. This is obviously a recognition of the fact that canned lima beans are acceptable at all maturity ranges and that substandard levels of quality for canned lima beans cannot be established on the basis of maturity, since there is little or no difference between dry lima beans that have been stored before soaking and processing and dry lima beans that are soaked and canned immediately after harvesting and vining.

Although the general relationship between A.I.S. and maturity of canned lima beans has been established satisfactorily (correlation of .92), the actual points of division between quality levels should be accepted only on a tentative basis, since they were established by one group of technologists from the Tri-State area only, and might need modification for application on a nation-wide basis.

**TABLE 7**
**Canned lima beans: relation of % A.I.S. to official scores for maturity**

| Grade A | | Grade B | | Grade C | |
|---|---|---|---|---|---|
| A.I.S. % | Score | A.I.S. % | Score | A.I.S. % | Score |
| 18.6 | 50 | 22.5 | 45 | 25.5 | 39 |
| 20.0 | 49 | 23.1 | 44 | 26.0 | 38 |
| 20.8 | 48 | 23.6 | 43 | 26.3 | 37 |
| 21.3 | 47 | 24.1 | 41 | 26.8 | 35 |
| 21.9 | 46 | 25.1 | 40 | | |

**Frozen lima beans.** The official U.S.D.A. Grades for Frozen Lima Beans provide for the grading of the beans on the basis of 2 factors. They are "defects" and "color" *(7)*. In the past, with such varieties as Henderson bush beans, the color score adequately took care of the problem of "maturity" grading. Today with the green-seeded varieties that is not the case. It is possible, of course, to measure the maturity of frozen lima beans on the basis of A.I.S., total solids or flotation methods. However, these methods of maturity grading have serious pitfalls.

These studies have indicated that there is a good correlation between A.I.S. and taste panel scores for the maturity factor of frozen lima beans (Figure 13).

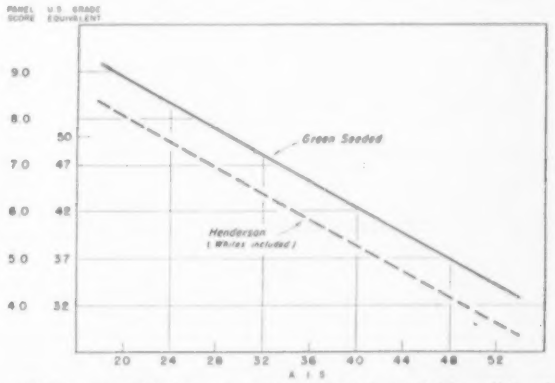


**Figure 13. Relation of percent alcohol insoluble solids of frozen lima beans to maturity scores as obtained by a panel of food technologists and U. S., P. M. A., graders.**

There is one problem, however, in considering A.I.S. as a basis for maturity grading of frozen lima beans. In contrast to canned lima beans, frozen lima beans are not processed in brine and hence do not soak up a given quantity of liquor during and after processing. Since it can be demonstrated that mature lima beans can more than double their weight by soaking up water *(4)*, it is obvious that percent A.I.S. of frozen lima beans may be reduced to any desired level by extending the blanching period or by soaking in cold or hot water. Such a procedure is demonstrated in Figure 14 where dried baby lima beans were soaked in tap water and boiling water for different periods of time.

It should be noted that as the duration of the soaking treatment is extended, the weight of the beans increases. At the same time, of course, the total solids and the specific gravity decreases. Since flotation methods of grading are also based on differences in specific gravity, these methods which are generally poorer than the A.I.S. method, though they have the advantage of greater simplicity, are even less applicable than A.I.S. If a soaking procedure were to be included in the method itself, it may be assumed that A.I.S. or percent floaters might then be used to determine maturity of frozen samples which will have been thawed and soaked in some prescribed manner. However, such a procedure would be questionable and would eliminate the "rapid" feature of a flotation method.

Turning to the possibility of utilizing a color measurement as an objective basis for evaluating the dominant factor of quality in frozen lima beans, a study was made of the possible use of the Hunter color difference meter, which has been found to be satisfactory for the measurement of color of other products *(2)*. The results presented in Table 8 indicate that measurement of diffuse

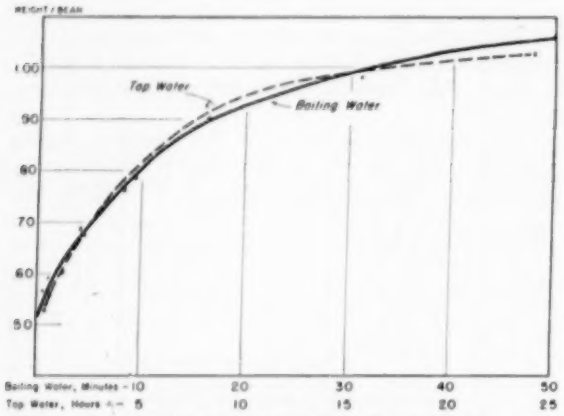


**Figure 14. Increase in weight of dry baby lima beans soaked in tap and boiling water for different durations of time.**

**TABLE 8**
**Correlations between Hunter color difference values and panel scores of frozen lima beans**

| Panel X | All samples | Green beans only | Green and white samples |
|---|---|---|---|
| Hunter "L" | −.623 | −.836 | −.642 |
| Hunter "a" | +.477 | +.552 | +.570 |
| Hunter "b" | +.307 | +.635 | +.326 |
| Hunter L, a, b | .654 | .842 | .756 |

reflectance is most closely correlated with human evaluation of color and maturity as well and that little additional accuracy is to be gained from the *a* and *b* values.

Thus in contrast to the tomato problem for example, where "hue" is the outstanding characteristic of color of interest to the consumer *(2)*, in the case of lima beans it is diffuse reflectance, or lightness. Thus the darker the lima bean color, the more acceptable it becomes; differences in the direction of yellow or green are of little importance. The relation of the Hunter "L" values to panel scores are presented in Figure 15, and their interpretation in terms of grade scores, in Table 9, where 60 is the maximum score for color.

Since color evaluation of lima beans is a relatively simple problem involving only one color characteristic,

**TABLE 9**
**Frozen lima beans: all green only; relation to Hunter "L" scale values, and % A.I.S., to official scores for color**

| Grade A | | | Grade B | | | Grade C | | |
|---|---|---|---|---|---|---|---|---|
| "L" | Score | A.I.S. | "L" | Score | A.I.S. | "L" | Score | A.I.S. |
| 29 | 60 | 29 | 36 | 53 | 36 | 42 | 47 | 44 |
| 30 | 59 | 30 | 37 | 52 | 37 | 43 | 46 | 46 |
| 31 | 58 | 31 | 38 | 51 | 39 | 44 | 45 | 47 |
| 32 | 57 | 32 | 39 | 50 | 40 | 45 | 44 | 48 |
| 33 | 56 | 33 | 40 | 49 | 41 | 46 | 43 | 49 |
| 34 | 55 | 34 | 41 | 48 | 43 | 47 | 42 | 51 |
| 35 | 54 | 35 | | | | | | |

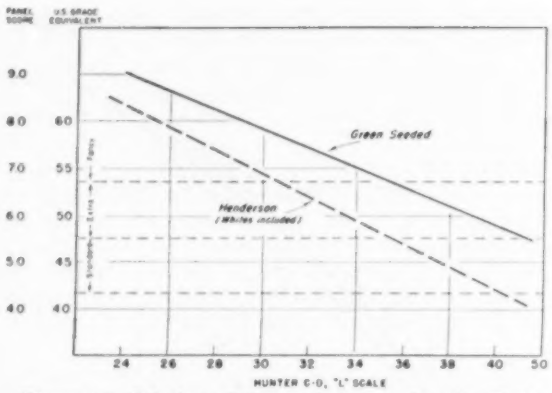


**Figure 15. Relation of "L" scale values (on the Hunter color-difference meter) of frozen lima beans to maturity scores as obtained by a panel of food technologists and U. S., P. M. A., graders.**

it should be possible to use a simpler and less expensive colorimeter than the Hunter color difference meter. However, for Governmental agencies and for firms processing several different foods, it may be advisable to use the versatile Hunter color difference meter for color measurement of a number of products and at the same time take advantage of its unusually good precision, accuracy, and ease of manipulation.

## CONCLUSIONS

Procedures for determining grades of raw, canned and frozen lima beans are presented, and their use on a tentative basis is recommended. Although the methods themselves are sound, it may be necessary, in the light of additional experience to modify them. The actual levels of quality must be examined carefully on an industry wide basis with possible adjustment in the assignment of actual grade scores to the values obtained by the methods described.

### Acknowledgment

Acknowledgment is gratefully made to the many growers, processing firms, and the State and Federal inspection staff in Maryland, Delaware and New Jersey, who generously provided in their respective capacities the materials, facilities, labor and technical assistance which made this work possible.

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# Thermal Inactivation of Pectolytic Enzymes in Genuine Dill Pickles[a,b,c]

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(Manuscript received June 23, 1953)

**The satisfactory pasteurization of genuine dill pickles requires a balance between sufficient pasteurization to destroy pectin polygalacturonase-like enzyme activity and microorganisms capable of causing spoilage and overpasteurization, which results in a softening of the pickle and development of cooked flavors.**

In a previous report Esselen and Anderson *(3)* reviewed work on the pasteurization and softening of genuine dill pickles, Jones *et al. (5)*, Jones *et al. (6)*, and Wenzel and Fabian *(8)*, and reported studies on the pasteurization of this type of pickle in quart jars. During the 1952 season, further work on the pasteurization of genuine dill pickles was carried on, as reported herein. Previous work in this laboratory was repeated and checked. Thermal inactivation data for polygalacturonase like activity in dill pickle brines was obtained, and the pasteurization of dill pickles in gallon jars was studied.

## EXPERIMENTAL PROCEDURE

Dill pickles were fermented in 45-gallon barrels. Three-to-six-inch pickles were used because most of them were to be packed in quart jars. The cucumbers (National variety), plus 8 pounds of fresh dill weed and one pound of mixed pickling spices per barrel, were placed in barrels headed and filled with 20°-salometer brine plus one gallon of 4% acid apple vinegar per barrel. The pickles were fermented at a temperature of 70 to 85° F. for 5 to 6 weeks and were then used in the experimental work. At the end of the fermentation period the titratable acidity of the brines varied from 0.88 to 1.21%, calculated as lactic acid. Care was taken to maintain the brine level of the pickles during fermentation.

Experimental packs of the dill pickles were put up in quart and gallon jars for storage tests, as previously described *(3)*. After 8 months' storage at room temperature the experimental packs of pickles were evaluated organoleptically for flavor and texture by members of the Department staff.

Heat penetration data on 24 quart jars and 24 gallon jars of dill pickles were obtained according to the method described by Esselen *et al. (4)*.

Thermal destruction data were obtained at temperatures of 135, 140, 145, 150, 155, and 160° F. for pectin polygalacturonase-like activity in the original dill pickle brine after fermentation was completed. The general procedure of Kaplan *et al. (7)*, using thermal death time tubes, was followed. Three tubes, each containing 2 ml. of dill pickle brine, were heated at each time and temperature interval. The heated brine samples from the 3 tubes were combined, and 5 ml. were used in the test for polygalacturonase activity by the method described by Bell *et al. (2)*.

## RESULTS AND DISCUSSION

As may be seen in Table 1, a pasteurization time of 25 to 30 minutes at 180° F. for quart jars of dill pickles was adequate to prevent microbiological spoilage and enzymatic softening of the product during storage. These observations are in agreement with those previously reported *(3)*. Gallon jars of pickles required a pasteurization time of 35 to 40 minutes to achieve the same results.

**TABLE 1**

**Effect of pasteurization time at 180° F. on the flavor and texture of genuine dill pickles in quart and gallon jars (samples examined after storage for 8 months at room temperature)**

| Past. Time | Texture | Flavor |
|---|---|---|
| **Quart Jars** | | |
| **Pack No. 1** | | |
| 0 | Very soft, slippery | Spoiled |
| 5 | Very soft, slippery | Spoiled |
| 10 | Very soft, slippery | Off-flavor |
| 15 | Soft | Very good |
| 20 | Slightly soft | Very good |
| 25 | Firm | Very good |
| 30 | Firm | Very good |
| 35 | Slightly soft | Slightly cooked |
| 40 | Slightly soft | Slightly cooked |
| **Pack No. 2** | | |
| 0 | Slippery, soft | Off-flavor |
| 5 | Soft | Off-flavor |
| 10 | Slightly soft | Slightly off-flavor |
| 15 | Slightly soft | Very good |
| 20 | Firm | Very good |
| 25 | Firm | Very good |
| 30 | Firm | Slightly cooked |
| 35 | Firm | Slightly cooked |
| 40 | Firm | Slightly cooked |
| **Gallon Jars** | | |
| 0 | Very soft, slippery | Off-flavor |
| 5 | Very soft, slippery | Off-flavor |
| 10 | Very soft, slippery | Very good |
| 15 | Very soft, slippery | Very good |
| 20 | Very soft, slippery | Very good |
| 25 | Soft | Very good |
| 30 | Slightly soft | Very good |
| 35 | Good | Very good |
| 40 | Good | Very good |
| 45 | Slightly soft | Very good |

Heat penetration data and sterilizing values ($F_{160}$) for the slowest heating quart and gallon jars observed in a number of runs are summarized in Table 2 and Figure 2. Thermal destruction data for pectin polygalacturonase activity in dill pickle brine are presented in Figure 1. Data for brines from 4 different barrels were in agreement. From Figure 1 it may be seen that this enzyme activity in dill pickle brine had an $F_{160}$ value of 1.85 (required 1.85 minutes at 160°F. for destruction) and a z value of 17.7° (number of degrees, ° F., traversed by thermal destruction curve in passing

[a] Contribution No. 900, Massachusetts Agricultural Experiment Station.

[b] Acknowledgment is due the Glass Container Manufacturers' Institute, Inc., for its interest and support in the conduct of this investigation.

[c] Presented before the Thirteenth Annual Meeting of the IFT, Boston, Massachusetts, June 23, 1953.

through one log cycle). Considering the variations in heating rates encountered between individual jars, data in Tables 1 and 2 are in general agreement with thermal destruction data for the polygalacturonase activity in dill pickle brine. They provide evidence to show that a pasteurization treatment of sufficient intensity to destroy the polygalacturonase activity will prevent softening of the dill pickles during storage.

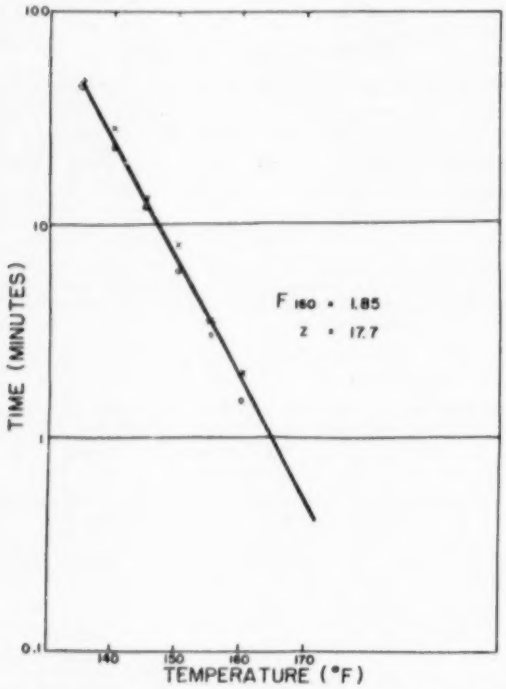


**Figure 1. Thermal destruction curve for pectin polygalacturonase in dill pickle brine.**

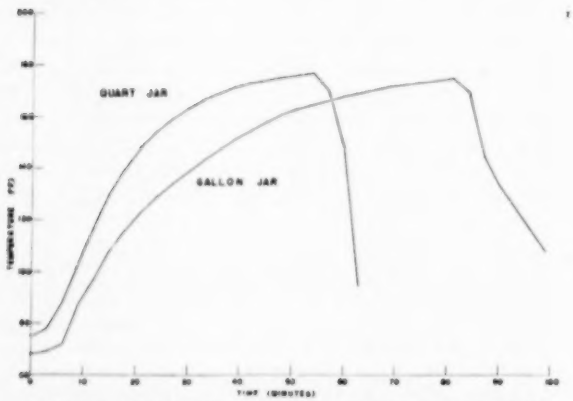


**Figure 2. Heat penetration curves for quart and gallon jars of genuine dill pickles pasteurized in water bath at 180° F.**

**TABLE 2**

**Sterilizing value ($F_{180}$) received by quart and gallon jars of genuine dill pickles pasteurized in water at 180° F.**

| Past. Time Min. | Quart Jars Slowest Heating Rate $F_{180}$ | Gallon Jars Slowest Heating Rate $F_{180}$ |
|---|---|---|
| 0 | — | — |
| 5 | — | — |
| 10 | — | — |
| 15 | — | — |
| 20 | 0.5 | — |
| 25 | 2.5 | — |
| 30 | 10.5 | — |
| 35 | 21.3 | — |
| 40 | 44.0 | 0.7 |
| 45 | 66.0 | 2.2 |
| 50 | 102.0 | 2.8 |
| 55 | | 9.9 |

The dill pickles in these tests had a rather high degree of pectin polygalacturonase activity at the time the experimental work was carried out. Five ml. of the original brine caused an almost complete loss in viscosity of a 3% pectin solution in following the method of Bell *et al. (2)*.

## SUMMARY

Thermal destruction data for pectin polygalacturonase in genuine dill pickles were correlated with heat penetration data for quart and gallon jars of the pickles. Pasteurization procedures based on these data resulted in retention of quality of the product during storage.

The satisfactory pasteurization of genuine dill pickles requires a balance between sufficient pasteurization to destroy polygalacturonase-like enzyme activity and microorganisms capable of causing spoilage and over-pasteurization which results in a softening of the pickle and development of cooked flavors.

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## SELECTED ABSTRACTS

(Continued from page 23 preceding technical papers)

## FOOD AND FOOD TECHNOLOGY

### BEVERAGES

**Making good sugar-free drinks.**

SANDRI, R. M. *Food Eng., 25,* 79+, May, 1953.

Remedies for problems (foaming, body, flavor) encountered in synthetic sweetening of beverages are presented. State laws regarding synthetic sweeteners are mentioned.

### CEREALS AND GRAINS

**Pillsbury manufactures wheat base concentrate.**

*Northwest. Miller, 250,* 18, September 8, 1953.

The product is used by the Army to make a whole wheat type bread by substituting the wheat base concentrate for 10-20% of the white flour normally used. The outstanding characteristic of wheat base concentrate is said to be its full-bodied wheat flavor. In addn., it can be stored for periods which exceed one year, whereas normal whole wheat flour can only be stored for relatively short periods without losing its flavor, particularly in the summer months.

### FISH AND SEAFOOD

**Deep fat frying of breaded fish and shellfish.**

HOYER, H. G. *Fishing Gaz.* (Annual Review No.), *69,* 166+ (1952).

A guide for handling shortening in the deep-fat frying process. Frying shortenings should be melted slowly at a temp. not above 300° F. and should be kept at an optimum temp. to prevent increased fat absorption. Proper fat level and shortening replacement should be considered.

### GELATIN AND GUMS

**The variation of the viscosity of gelatin sols with temperature.**

CROOME, R. J. *J. Appl. Chem., 3,* 330-4 (1953).

The variation of the viscosity with temp. was studied on sols. of an isoelec. ossein gelatin, and representation of this variation was found possible by means of an equation of the type $\eta = Ae^{K/T}$. The term A is shown to be a function of the percentage (wt.) concn. of gelatin in the sol. A working hypothesis was made that the hydration of the gelatin particles during soaking, persists on dispersion; the decrease in viscosity with rising temp. is represented as due, in the main, to a progressive loss of the absorbed water back to the free dispersion medium, thereby decreasing the ratio of wt. of dispersed phase to wt. of dispersion medium. Expression of the viscosity as a function of this ratio yielded an equation representing the variation of the viscosity with concn. of gelatin. The reversibility of the viscosity-temp. variation is explained as being due to the rupture and subsequent reformation of hydrogen bonds set up between the water mols. and the lyophilic peptide groups in the gelatin particles.

### MILK AND MILK PRODUCTS

**Dairy products improved by ion exchange.**

GARRETT, O. F. *Food Eng., 25,* 61+, July, 1953.

Dried creams that disperse rapidly in hot coffee, special dried milks, and heat-stable evapd. milks are some of the products made possible by use of new exchanger materials.

**Dehydrated foods. Chemical changes in dehydrated milk during storage.**

SHIPSTEAD, H., AND TARASSUK, N. P. *J. Agr. Food Chem., 1,* 613-16 (1953).

A review. *29* references.

### PECTIN

**Pectin grading. Application of intrinsic viscosity.**

SWENSON, H. A., SCHULTZ, T. H., AND OWENS, H. S. *J. Agr. Food Chem., 1,* 616-20 (1953).

A study was undertaken to provide further information on tests for pectin grading, as a poll of American preservers has shown 71% in favor of a breaking measurement of the plunger type and 24% in favor of a rigidity measurement. A balance-plunger app. was developed, by which both small deformations and breaking strengths can be measured. Grades obtained from these measurements generally differ, but curves of intrinsic viscosity vs. grade can be used to est. grade by elasticity, if grade by breaking has been detd., or the reverse if grade by elastic modulus has been detd. The curves and viscosity measurement alone offer a rapid and fairly reliable means of obtaining pectin grade values that would be procured by gel measurements of both types.

**Properties of purified fungal polygalacturonase.**

RAHMAN, Md. B., AND JOSLYN, M. A. *Food Research, 18,* 301-4 (1953).

PG free from PE (pectin esterase) was prepd. from 3 com. fungal sources. All the purified PG preps. were similar in their properties, the most appreciable difference being in the range of pH at which optimum activity was observed. The pH optimum for PG action on pectic acid was in the range of pH 4-5; the temp. optimum was in the range of 45-55° C.; and the PG activity was in general resistant or only slightly affected by the usual inhibitors. PG activity was very slight at pH 3, and inhibited at pH 7.5-8.0. For prolonged storage, inactivation of PG activity in the presence of pectic acid and products of hydrolysis occurred at pH 9.0 and this inactivation was found to be reversible.

### POULTRY

**Some protein changes in stored frozen poultry.**

SWANSON, M. H., AND SLOAN, H. J. *Poultry Sci., 32,* 643-9 (1953).

Proteolysis was indicated during frozen storage by increases in sol. N and non-protein N of both leg and breast muscle. Decreases in amino N suggest that certain metabolic processes must be continuing in the frozen state causing further breakdown of the amino acids formed by proteolysis. Although the analysis of variance showed that the observed changes were highly significant, F values also indicated that there was a significant difference among birds in the rate of proteolysis.

### STARCHES

**Starches tailormade for users.**

WHITE, T. A. *Food Eng., 25,* 95+, June, 1953.

A table is given showing phys. properties (cell size, gelatinization temps. at various concns., texture, clarity) of several com. raw starches.

## INDUSTRIAL CHEMISTRY

**Cost control in the chemical industry. I. Costing principles and methods.**

DYSON, G. M. *Mfg. Chemist, 24,* 231-5 (1953).

This series of articles is designed for the chemist to acquaint him with costing principles in chem. processing. The author uses the manuf. of specific chemicals as examples to explain how the cost of raw materials, cost of labor, and the oncosts are estd.

## ORGANIC CHEMISTRY

**Improved isolation of L-arabinose from mesquite gum.**

CRAMER, F. B. *J. Franklin Inst., 256,* 93-4 (1953).

A less cumbersome method has been discovered for the removal of impurities with improved yields of L-arabinose from

(Continued on page 28)

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# If a crystal can tell your future, be sure you have the right CRYSTAL

THERE ARE many kinds of crystals in the world. One variety is the crystal ball which is supposed to be able to predict your future. There is some doubt about that. Another is the pure, uniform crystal of monosodium glutamate you get when you order Ac'cent. That crystal can *influence* your future. There is *no* doubt about that. Case histories on hundreds of products using Ac'cent prove how sales leap when Ac'cent is added to a food operation.

One of the many advantages in ordering Ac'cent is that you are assured of monosodium glutamate in its purest, most convenient form. The Ac'cent crystal is free of all foreign ingredients. Standard size crystals will not cake or lump—they do not cling to the sides of containers or dispensers. This results in a uniformity of flavor that pays off in repeat sales.

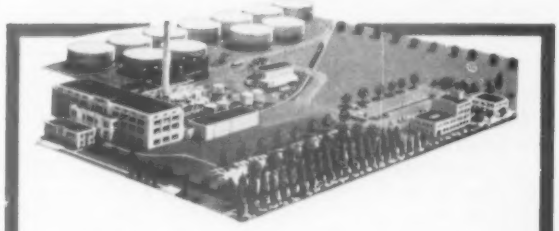
Ac'cent, you see, is the sole product of Amino Products Division, and, therefore, receives all the attention and care of an only child. For that reason you can always be sure you are getting monosodium glutamate at its best when you order Ac'cent.

And because Ac'cent was the pioneer in the field, and continues with an ever-increasing program of research and development, you receive so much extra in the way of information and service. For instance, a 75-man research and development team is constantly at your service to show you how to get the flavor maximum out of your product in the most economical way...even to the point of designing special machines for your particular operation. And all the information gleaned from 10 years of continuous research is constantly made available to the industry. In 1952 alone, 753,249 printed information pieces were mailed to food processors.

Consumer acceptance is another Ac'cent project, and a very successful one. A long-range educational program was launched several years ago to explain monosodium glutamate to the consumer. Housewives now are looking for it on your labels in their grocery stores.

With the growing awareness of monosodium glutamate on the part of consumers and food processors, Ac'cent has expanded its services. A new research center was recently completed in Skokie, Illinois, and an addition was made this year to the Ac'cent plant at San Jose, California. Supplies are now located in convenient warehouses at 39 points throughout the United States and Canada, assuring food processors of a quick and abundant supply of Ac'cent.

The next time you order monosodium glutamate, remember the many advantages that can only be offered by the leader in the field. Remember that a crystal can influence your future...so be sure you choose the right crystal. Specify Ac'cent. You get so much more when you do.



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## SELECTED ABSTRACTS

(Continued from page 25)

mesquite gum. It is based on the fact that the major portion of the by-products contains uronic acid residues which are ionizable and may be easily removed by the use of ion-exchange resins. After hydrolysis in $H_2SO_4$, neutralization and filtration by established procedures, the soln. is passed through columns of Amberlite IR-120 and Duolite A-4. The water is evapd. and the residual sirup dissolved in MeOH. Arabinose seps. in good yield as white, odorless crystals of purity sufficient for most uses without recrystn.

**Synthetic tuberculostats. V. Alkylidene derivatives of isonicotinylhydrazine.**

Fox, H. H., and Gibas, J. T. *J. Org. Chem., 18,* 983-9 (1953).

A series of 21 alkylidene and arylalkylidene derivs. of isonicotinylhydrazine was prepd. and studied for tuberculostatic activity. All of them were active and the *in vivo* activities of several of them are greater than that of any known synthetic tuberculostat other than that of isonicotinylhydrazine itself.

## PACKAGING

**Chemical applied to wraps will curb mold in cheese, protect other foods.**

*Packaging Parade, 21,* 88-9, September, 1953.

Sorbic acid applied to cheese wrappers retards the growth of mold on cheese. The fatty acid is harmless, odorless, tasteless and colorless, and provides food value itself. Prior to use of material, cheese packaged in moisture-proof film still had mold growth.

## RADIOCHEMICAL TECHNOLOGY

**Setting up a radiochemical laboratory: 2.**

*Mfg. Chemist, 24,* 243-5 (1953).

Recommendations for shielding from gamma rays and a description of the instruments suitable for the four classes of radiochem. lab.—"tracer," "warm," "semi-hot" and "hot"—are given.

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*National Preparedness Benefited by Research and Development Associates.* Among the many non-profit organizations in the United States that are devoted to the public welfare and security of the nation, the Research and Development Associates, Food and Container Institute, Inc. has a function of unique importance. Founded in 1947 to perpetuate the effective wartime cooperation of research groups within the food industry, the container industry, and various publicly supported or endowed institutions across the nation, it has continuously provided on a *gratis* basis the technical counsel of specialists in every field of inquiry useful in improving military subsistence and packaging. It has also been instrumental in disseminating to research and development personnel in these fields information on food and container problems of concern to the Military and the progress being made in alleviating or solving them. In a period when the whole-hearted support of national preparedness cannot be relaxed for a moment the contributions of the Associates are invaluable. Further information on the mission and purposes of the Research and Development Associates, can be obtained from Col. Rohland A. Isker, QMC, ret'd, The Associates, 1849 West Pershing Road, Chicago 9, Illinois.

***. . . in the public interest***

Heigh-ho! Heigh-ho! It's off to school we go! For leading off the January column are two important school news notes—to-wit:

The 33rd Annual Food Processors School of the Oregon State College Food Technology Department has been scheduled for the following dates: January 25 through February 5, Closing Machine and Double Seaming School by American Can Company; February 3 through February 7, 33rd Annual Food Processors School; February 8 through February 19, Closing Machine and Double Seaming School by Continental Can Company. The week of lectures starting February 3 will cover the fundamentals of canning and freezing, together with talks on allied subjects. Chairman of the Short Course Committee is Dr. Curtis J. Wilder, Department of Food Technology, Oregon State College, Corvallis.

The American Institute of Baking, 400 E. Ontario St., Chicago 11, Ill., announces the availability of a limited number of scholarships for college students or graduates who wish to prepare themselves for opportunities in the baking industry. The stipend of $750 will provide major financial assistance for a 20-week course that entails intensive study of production baking, supervision, and management. Applicants will be judged on the basis of: (1) scholastic achievement and participation in school activities; (2) extent of study of physical science, business administration, or engineering; (3) experience in the baking industry (not requisite); and (4) financial need. Applications now received will be considered for classes starting February 1, 1954, and August 2, 1954. Forms may be obtained from the School of Baking at the above address. Announcement of awards will be made approximately two months before the opening of each class.

◆ ◆ ◆

A grant of $10,000 in support of research related to new uses for inedible animal fats (tallows and greases) has been accorded by the National Renderers' Association to the American Meat Institute Foundation, it was announced by Dr. H. R. Kraybill, Foundation director of research and education. Mr. Ralph E. Schaeffer, who recently received his M.S. degree in organic chemistry from the University of Iowa, has joined the staff of

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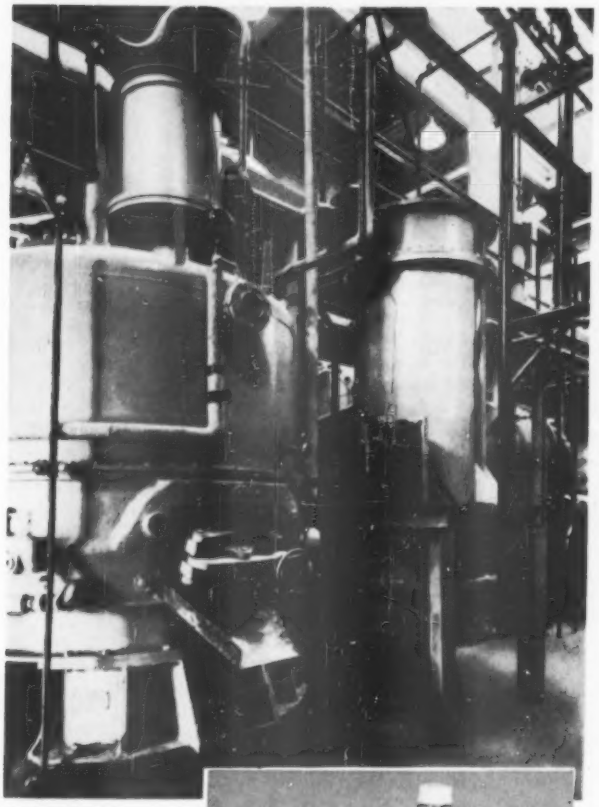
# Takes the WAVER OUT of spice flavor...



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## FOOD INDUSTRY TOPICS

(Continued from page 28)

Dr. L. R. Dugan, chief of the Foundation's Division of Organic Chemistry, to undertake this work. Initially, Mr. Schaeffer is conducting fundamental studies on oleic acid and its esters. These studies are designed to define conditions which will restrict the sites of oxidation and limit the formation of secondary oxidative products during the manufacture of various compounds derivable from animal fats. It is hoped that the fundamental data developed in this and other aspects of the research may provide the basis for more economical production of long-chain oxygenated products, such as dibasic acids, which are finding progressively increased utility in industrial applications.

◆ ◆ ◆

Forecasting tremendously increased markets for processed foods, Mr. L. M. Richardson of the Foxboro Company, Foxboro, Mass., told the Northeast Section of the IFT that successful companies will handle the new volume by increasing their efficiency through sound engineering and greater use of instrumentation. Speaking at the November meeting, IFT member Richardson pointed to the growing U. S. population, creating new customers for processed food. The fact that a smaller total number of food companies is serving the field is attributed to difficulties in lowering production costs and increasing production volume while maintaining uniform quality. The facts, he said, point to one solution: a sound engineering program to build efficiency. One phase of this program should be modern instrumentation, which is one of the surest ways to get a higher quality product and greater production from present plant equipment. That the situation is recognized, he continued, is evident from the trend of the more modern plants in streamlining their operations—going from batch to continuous processing, and eliminating tedious manual operations wherever possible. In all of these efforts, instrument engineering is not only valuable, but essential.

◆ ◆ ◆

More than 1,500,000,000 cans of pet food—doubling the production of five years ago—will be used in the feeding of the nation's 49.3 million dogs and cats in 1953, an American Can Company survey reveals. There are 22.6 million dogs and 26.7 million cats. Six years ago a similar study—counting dogs only—showed a canine population of 17 million, which means that Man's Best Friend has been increasing at the rate of about 900,000 a year, stated the can-making firm, which helped develop the first balanced canned dog food diet in the late 1920's. The survey, conducted through the services of National Family Opinion, Inc., shows that nowadays 78 percent of all dog owners purchase foods expressly for their pets, and 58 percent of all cat owners do the same. Although the study separates the dogs from the cats, and classifies each group into farm, urban, and rural non-farm pets, the analysis brought out the fact that the 17.5 million *urban* animals are the principal consumers of packaged commercial pet food. However, despite the socio-economic levels of the animals, the Canco survey reveals that they all enjoy eating.

◆ ◆ ◆

Consumers prefer and will even pay more for items in packages which provide ease of buying, storing, and opening, a packaging expert advised the food trade. The expert, Mr. Robert K. Gibbs, president of Tri-State Plastic Molding Co., Inc., Henderson, Ky., pointed out that sales and profits are definitely going to manufacturers who stress convenience in their packaging as well as in their products. Gibbs suggested the basic criteria in developing packages to please the consumer should be light weight, transparency, squareness, cleanliness, and safety. These, he concluded, are best met by plastic packaging.

◆ ◆ ◆

Housewives like to buy potatoes bagged in printed polyethelene, it has been proven by the University of Maine. Furthermore, if the choice is between unwashed and washed potatoes both bagged in polyethelene, housewives overwhelmingly prefer the cleaned, washed "spuds." Finally, when potatoes are packed in printed polyethelene bags, over-all potato sales markedly increased—a most important factor for a product whose per capita consumption has been steadily declining. These findings have been released by the University of Maine Agricultural Experiment Station. They are based on the nation's first survey on sales appeal of washed vs. unwashed potatoes packed in printed polyethelene, and on the acceptability of washed potatoes in various types of packages. The studies were made over a six-week period at supermarkets in Boston, Worcester, and Bangor, Me., using polyethelene bags produced by Nashua Corp. of Nashua, N. H., from film supplied by Olin Industries, Inc. Further details of the test are available from the University of Maine Agricultural Experiment Station, Orono, Me.

◆ ◆ ◆

The dairy industry faces a formidable competitor in the chemical industry, Prof. Milton E. Parker, director of the food engineering department at Illinois Institute of Technology, Chicago, warned in a recent magazine article. Writing in the November issue of *Technology Review*, Prof. Parker pointed out that many important low-cost foods can be converted to high-quality protein sources through the addition of amino acids. He said the four amino acids most needed for improvement of human dietaries are lysine, methionine, threonine, and tryptophane. In areas where bread and other foods derived from wheat are important staples, substantial over-all improvement in protein nutrition possibly can be realized by fortification with lysine alone, he stated. The prediction was given added importance recently when DuPont announced that its patent rights on the use of lysine have been registered as a free license for use by any interested form on a royalty-free basis. DuPont already has perfected a process for synthesizing lysine and is making experimental quantities available to millers and food manufacturers for evaluation. Combinations of the four amino acids can be effectively utilized to enhance the protein nutritional quality of other dietaries, Prof. Parker explained, such as those based on rice, potatoes, and legumes. In many instances, it is not at all unrealistic to predict that the effective supply of dietary protein can be increased markedly through mere amino acid supplementation, provided the basic economic problems of combining or adding these four amino acids can be solved, he asserted. The dairy industry's future as a technological leader among food industries—and its own industrial pre-eminence and survival—may reside in the outcome of the battle of high-quality proteins, Prof. Parker emphasized.

### . . . *things new under the sun*

After three years of extensive testing, an entirely new method of cold galvanizing for surface protection of steel and iron has been announced by the Galvicon Corp., 40 W. 29th St., New York 1, N. Y. This new process, which utilized Cold Galvanizing Compound, is not a paint, but actually a cold galvanizing compound. Despite its considerably lower cost, "Galvicon" reportedly equals and in many cases outperforms other surface protection techniques including electroplating, hot-dipping, cementation, spraying, and painting. The coating has found a wide variety of uses, in plants and factories in every field from food processing to textile manufacturing — wherever rust occurs on machines, equipment, or outside installations. The compound may be applied with an ordinary paint brush, electric spray gun, or by cold dip. Special equipment or personnel training is not necessary. "Galvicon" is said to differ basically from other so-called metallic paints containing zinc, in that it actually combines the base metal, setting up electrical continuity. It offers true cathodic protection, leaving a coating in excess of 96 parts by weight

(Continued on page 32)

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Grapefruit 5-Fold
Grapefruit Terpeneless
Lemon California, Cold Pressed U.S.P.
Lemon 5-Fold
Lemon Terpeneless
Lemon Sesquiterpeneless
Limes Distilled
Limes Expressed
Limes 5-Fold
Limes Terpeneless
Mandarin (Tangerine)
Mandarin 5-Fold
Orange California, Cold Pressed U.S.P.
Orange Florida, Cold Pressed U.S.P.
Orange Distilled
Orange 3-Fold
Orange 5-Fold
Orange 10-Fold
Orange Terpeness
Orange Sesquiterpeneless

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## FOOD INDUSTRY TOPICS

(Continued from page 30)

of chemically pure zinc, which is the minimum zinc content for true galvanic protection. In instances where "Galvicon" is directly applied onto adhering rust, it induces the rusted area to create its own non-flaking coating, thereby stopping any further rust and preventing "rust creep." The product also is said to eliminate the costly, time-consuming, and often impractical necessity of dismantling required by other zinc processors. "Galvicon" can be applied directly to the object, regardless of size. A single coating of "Galvicon," brushing consistency, will give a coverage of approximately 625 square feet per gallon. Within 40 minutes after application, the coating will be tack-free and will be completely dry for use within 48 hours. The dried film of "Galvicon" contains nothing injurious to health. The product is available in cans in four sizes: ½-pint, quart, gallon, and 2-gallon. Technical literature and price lists available from the company on request.

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Development of a new package for a summer drink concentrate which combines complete moisture-proof protection with sales appeal and sufficient rigidity for proper display has been announced by Packaging Products, Inc., Kansas City, Mo. Designed for Thomas & Dunn, Inc., Memphis, for their "Rebel-Aid" line of powdered summer drinks, the package is a combination of printed Olin cellophane with a laminated, heat-sealed, lacquer-coated glassine liner. It was decided to make the bag "sift-proof" by fabricating the bag completely with heat to eliminate the bubbles sometimes found in glue lines along the seams. Since no solvent is required in heat sealing, the concentrate cannot pick up the sealant odor. The Rhinelander 58 No. DHS-coated Laminated Pouch Liner gives full protection to the contents, according to Mr. A. Ralph Krigel of Packaging Products, designer of the package. "The Olin Cellophane outer bag permits us to use illustration and printing to best advantage for eye appeal," Mr. Krigel said.

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Quartz Products Corp., 25 Crowsmill Rd., Keasbey, N. J., announces the development of the "Epiradiator"—used for evaporation of liquids in laboratory work. Instead of inducing evaporation by boiling, the surface of the liquid is subjected to calorific radiation from the Epiradiator. The energy is absorbed by the surface layer, thereby producing evaporation while the remainder of the liquid and the vessel itself remain relatively cold. This method of evaporation insures a clean and perfect residue, no boil over, and rapid operation. Manufactured of fused silica, the Epiradiator is moisture-proof and acid-resistant. Units come in four sizes for operation on 110 or 220 volts.

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A new source for top quality Oil Lemon, a product of which there has been an ever increasing shortage for over a year, was announced by Dodge & Olcott, Inc., 180 Varick St., New York City. After four years of development and construction, W. Sanderson & Sons of Messina, Italy, producers of the world famous Italian Oil Lemon U. S. P., Messina, Hand Pressed, have brought the American market Oil Lemon from Argentina. Produced by means of the same growing methods, processing, and technical know-how that have characterized all Sanderson products for many years, the Argentinan Oil Lemon is of excellent quality and meets all U. S. P. specifications. Argentinal Oil Lemon is available only through D&O, sole agents for W. Sanderson & Sons in the USA, at its current price of $8.25 per pound, f.o.b. New York.

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A new, stainless steel Pressure Wall Multi-Process tank for heating, pasteurizing, cooling, or mixing has been developed by the Creamery Package Mfg. Co. for efficient processing of both large and small runs. A feature of the tank is the space controlled heat exchange, permitting the passage of heating or cooling media through one or more zones of the pressure jacket so that the heat exchange area matches the capacity of the run. The tank is furnished in sizes from 200 to 1000 gallons. Either water under pressure or steam may be circulated through the zoned pressure wall system. Controls for the system are provided with the tank. Full information can be obtained from the company, located at 1233 W. Washington Blvd., Chicago 7, Ill.

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An adjustable, vibration-resistant I-Beam clamp designed to handle requirements in process food and chemical, utilities, and steam piping systems is announced by The Globe Stamping Division, Hupp Corp., Cleveland, Ohio. The clamps are adjustable to various thicknesses of beams by means of a hardened set screw which clamps to the beam. A hex jam nut is used to lock the clamp and bolt firmly to resist vibration. The clamp body, formed of 9-gauge steel, is 2⅜" long by 2⅛" wide, with a ¾" opening to receive a variety of flange sizes. The lower clamp jaw, threaded to receive hanger rods, is available in four sizes to take ⅜", ½", ⅝", and ¾" hanger rods. The clamps are made of 1040 high carbon steel, providing excellent fatigue-resistant characteristics for long, trouble-free service. Further information may be obtained by writing to The Hupp Corp., 1250 W. 76th St., Cleveland 2, Ohio.

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Cellophane bags with seams so strong a blown-up empty bag can easily support the weight of a man were announced recently by Oneida Paper Products, Inc., Clifton, N. J. Secret of the new bag is a unique Oneeida bottom-seal closure which is approximately 40 percent stronger than normal adhesive-sealed seams, according to findings at Olin Cellophane's Product Evaluation Laboratory. Oneida used Olin Cellophane for the super-strong bags, which now are in production. The unusual seal strength makes the Oneida bags ideal for potato chips, crackers, and other perishables which lose their crispness when exposed to outside air. The seal slows down the inevitable seepage of air into any cellophane bag better than any other closure yet put on the market, says Oneida. The Oneida seal is a special type heat-seal-and-crimped reinforcement and is employed either with single or multi-wall cellophane bags. When multi-wall bags are used, a ribbon seal at the top of the bag, considered by Oneida superior to spot sealing, is employed so the cuplex walls do not separate on filling line production.

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Ion exchange resins pre-processed to make them suitable for chemical, medical, and physical laboratory applications are now available from BIO-RAD Laboratories, 800 Delaware St., Berkeley 9, Calif. Dowex starting material, supplied by Dow Chemical Company, is being more completely sized, purified by alternate acid, base, and organic-solvent cycles, and defined—by an individual analysis on each batch—covering moisture content, cross linkage, capacity, size distribution, and porosity. Designed to provide a source of pure, ready-to-use resins with known properties, this new grade of material will permit standardized, reproducible procedures to be carried on even at different locations, since the resin will be eliminated as an experimental variable. Resins presently available from stock, with various size distributions and cross linkages include four types processed from Dowex 50 (cation exchange), Dowex 1, 2, and 3 (anion exchange). These are extremely stable styrene type resins with capacities ranging from 5.2 milliequivalents per dry gram for Dowex 50 to 3.0 milliequivalents per gram for Dowex 2 starting materials. Resins with special cross linkages, special sizes, and very narrow distributions will be made available as required.

"Iron-Rubber," a new, protective sheeting that successfully combats abrasion and corrosion, is the latest addition to the expanding Magic-Vulc line produced by the Magic Chemical Co., Brockton, Mass. Easily and quickly installed, "Iron-Rubber" gives absolute protection, says the company, to all kinds of equipment for extraordinarily long periods of time. It is ideally applicable to chutes, hoppers and launders, ball mills, ducts and pipes, skips, housings, tanks, shaking tables, shot and sand blast cabinets, or other equipment normally subjected to excessive wear. "Iron-Rubber" is guaranteed to outlast the material it protects many times and adds to profits by minimizing maintenance costs, increasing the life of equipment, and increasing production by eliminating shut-downs for repairs. Two types of "Iron-Rubber" are available—reinforces and non-reinforced. The first is composed of two sheets of rubber permanently bonded to a central core of expanded steel. This type of sheeting can stand on edge without buckling, can be bent to fit corners without springback or can be shaped to fit practically any contour. Non-reinforced "Iron-Rubber" is a single sheet of rubber and is much more flexible than the reinforced type. Both versions of the product are light in weight and large sections can be easily handled by one man. The product can be made in any thickness and to any length up to 36" wide to meet individual needs. Complete details and prices may be obtained by writing to Mr. Louis Leaman, Magic Chemical Co., Dept. N250, 121 Crescent St., Brockton, Mass.

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According to tests made by the National Potato Chip Institute, the Steinlite model 200 LOS Oil Tester may prove a more acceptable way to determine the oil content of potato chips for potato chip processors. From a control standpoint, processors feel that it is important to know the oil content of potato chips for reasons of economy and control of rancidity. Heretofore, processors who made oil content determinations on potato chips used the carbon tetrachloride method and the ether extraction method. The Steinlite instrument uses a much faster, and fully as accurate, liquid cell electronic method of oil content determination, and only a semi-skilled operator is necessary. Techniques developed in making oil content determinations with the Steinlite Oil Tester involved crushing 50 grams of a a sample lot of potato chips, adding 100 milliliters of Steinlite solvent, placing mixture in a Waring Blendor for four minutes and then filtering. The extracted oil was handled like any other extracted oil in making final simple readings and conversions. For further information on the Steinlite 300 LOS Oil Tester write the Seedburo Equipment Co., exclusive distributors, 618 W. Jackson Blvd., Chicago, Ill.

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Clark Equipment Co., Buchanan, Mich., manufacturer of a broad line of industrial fork-lift trucks, towing tractors, straddle carriers, and related materials handling equipment, has established a low-cost equipment-leasing program to operate through its dealers on a national basis, according to an announcement by Mr. W. E. Schirmer, vice president. Financial arrangements for the program have been worked out with the Harris Trust & Savings Bank of Chicago. According to Mr. Schirmer, the program is not intended to promote the leasing of equipment in preference to outright purchase, but is being offered as a service to that segment of the industrial community which has need of a low-cost leasing arrangement. Such an arrangement is particularly attractive today because it frees working capital. Current high taxes, with little important relief in sight, means a "profitless prosperity," or a period comparable to 1946-49, when working capital requirements increased greatly, he continued. The leasing arrangement offers at least a partial solution to the problem, since it avoids the necessity of expending any capital funds for there is no down payment or advance money required.


extend **SHELF LIFE!**

retard **RANCIDITY!**

**...on High-Fat Low-Moisture Foods!**

● **As you know, potato chips, prepared mixes, nuts, baked goods, powdered soups and many other products that are high in fat and low in moisture are often spoiled by rancidity and the development of oxidative "off" flavors. And these factors reduce the shelf life and profit margin of many food products.**

***These problems may be avoided by the proper use of a new food grade salt with antioxidant, developed as a result of years of laboratory research—Diamond Crystal Salt with ANTIOXIDANT!***

**New Diamond Crystal Salt with *Antioxidant* is as simple to use as common table salt. If sodium chloride is used in your processing, this new salt will fit into your operation without extra equipment or labor.**

**Diamond Crystal Salt with *Antioxidant* is economical, too! The extra cost involved in salting potato chips is only about 7¢ per 100 lbs. of chips! This is a small cost to minimize returned goods.**

The effectiveness, ease of use and economy of this new salt will more than justify its test in your operation. Samples are available upon request. Send for yours today!

**Write to Technical Director, Diamond Crystal Salt Co., St. Clair, Michigan.**

**DIAMOND CRYSTAL SALT with Antioxidant**

## FOOD INDUSTRY TOPICS

Refrigerated boxes, designed to be knocked down into sections so they can be moved easily and reassembled as the occasion demands, are now being manufactured by Bailey Refrigeration Co., Inc., 115 King St., Brooklyn 31, N. Y. Measuring 12 x 18 x 8 feet, with storage capacity of approximately 1100 cu. ft., all units are self-contained with the machinery in an insulated section of the top of the box. The first boxes, for use by the Chilean Army, have just been exported through Gregg Industries, Inc., New York.

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A new technique has been developed whereby quantitative measurements of sulphur in a specimen have been performed successfully, according to a recent announcement from the Research & Control Instruments Division, North American Philips Co., Inc., 750 S. Fulton Ave., Mt. Vernon, N. Y. Equipment required consists of a standard Norelco Spectrograph with a new type goniometer housing which allows the Geiger Counter to travel to 146° (2θ) and permits use of helium instead of air in the X-ray path. Analysis of the results obtained from the new Philips technique leads to the conclusion that the method has a probable sensitivity limit of 0.05% sulphur in oils.

### . . . *the literary corner*

Leading off the November 15 *Information Bulletin* of The Refrigeration Research Foundation, 200 Midland Bldg., Colorado Springs, Colo., is a timely item on "USDA and American Agriculture." Taking note of the circular recently prepared by Secretary Benson and entitled "Strengthening American Agriculture through Research and Education," the *Bulletin* expresses the hope that editors and industry leaders will take advantage of the request for suggestions. It concludes: "Agricultural industry (which includes refrigerated warehousing) is included in the broad proposals for solution of agricultural problems. Emphasis falls on finding the newest and best ways to solve problems—the willingness to learn and the courage to do. The decisions that are made will reach far into the future."

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The Kleen-Kut Meat and Food Mixer, newest development of the Kleen-Kut Manufacturing Co., 5501 Denison Ave., Cleveland 2, Ohio, is described in literature and catalog sheets available from the manufacturer. The item has many features and advantages, not least of which is the fact that it is the only mixer in the low priced field with a 150-pound capacity. Because it is so versatile, the company claims it is a "must" for meat markets, hotels, restaurants, sausage manufacturers, and anyone processing or mixing meats and foods. The large, stainless steel tub tilts for loading and unloading and locks securely into an upright position for mixing. A new design series of stainless steel paddles assures rapid and thorough mixing or seasoning without crushing. A powerful ¼ h.p. motor provides non-stall action.

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While the do-it-yourself movement is becoming bigger among consumers, the "don't-do-it-yourself" idea is even more important in business and industry, says the November *York Report*, published by the York Engineering & Construction and York-Gillespie Manufacturing companies of Pittsburgh. Even engineering firms call in other engineering organizations when confronted with problems requiring specialized techniques, say the engineers who publish the *Report*. Not doing things for oneself benefits industry, they add, because specializing organizations can often do things cheaper as well as better than a company can do them for itself. In getting others to do things, management is liberated from masses of detail work, capital outlays can be reduced, and tax savings made. The privately circulated *Report* concludes: "The greatest advantage of all defies measurement in dollars or dividends. That is the speed that can come from letting others do things they are best equipped to do. Outward contracting may accomplish in months what inward training might take years to complete. And in that difference in time, who knows that markets may be lost, what leaderships won, what worlds vanquished? For parlous days ahead, free management of everything but the task of managing!"

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The Egg Solids Council, Division of the Institute of American Poultry Industries, has just published a 24-page brochure of considerable beauty entitled "The Inside Story, Egg Solids." (That's a yolk, son!) With widely increased use by bakers, confectioners, ice cream manufacturers and others who package complete mixes—cake, doughnuts, and the like—there is a growing interest in and need for information about egg solids. The brochure tells a fascinating word and picture story about research, processing, and uses, and stresses the fact that present-day egg solids are a new product wholly resultant from scientific and technological advances. During 1952, almost 600 million eggs were converted to egg solids and the forecast for 1953 is for even greater conversion. Contact Egg Solids Council, 221 N. LaSalle St., Chicago 1, Ill., for information on how to secure copies of the brochure.

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Complete information on a new line of Poly-Flo Tube Fittings for connecting polyethylene and other plastic tubing, manufactured by The Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago 7, Ill., is included in the company's Bulletin No. 3025-A. Featuring exceptional ease and speed of installation, Poly-Flo Fittings are of the compression type and consist of a brass body with integral tube support, brass nut, and polyethylene sleeve. Fittings can also be supplied in stainless steel for use with Teflon or other tubing. Fittings are now offered in two sizes—¼" and ⅜" O.D.—and additional sizes will be available shortly. Styles furnished include unions, half unions, elbows, tees, and bulkhead unions. There are also unions for connecting to metal tubing. Joints will hold burst pressures of .040" or .062" polyethylene tubing, it is stated, and are recommended for working pressures up to 125 p.s.i. in ¼" O.D. size and 100 p.s.i. in ⅜" O.D. size, and for temperatures from minus 90° F. to 175° F. Higher pressure and temperature limits apply when Teflon tubing is used. The new fittings and polyethylene tubing are said to be ideally adapted to instrumentation and many other applications such as food processing, beverage dispensing, dairies, laboratories, etc. Tubing is impervious to most solvents and chemicals and is non-toxic, odorless, and tasteless. It can be used with most liquids and gases. A number of accessories are included in the line.

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A six-page Bulletin No. 300, issued by Titeflex, Inc., Newark, N. J., describes that company's special type of metal expansion bellows for conveying gas and liquids. Test and diagrams explain the welded-diaphragm construction of the bellows and point out how this results in a bellows especially able to withstand high temperature, vibration, and corrosion. The bulletin also explains how this construction provides extreme flexibility for lines of low internal pressure while at the same time affording great strength to withstand high external pressures. It further points out that the expansion range of this type of bellows depends on the convolution's height, which can be easily made of any desired value. Hence, relatively long expansion ranges can be provided by bellows of rather short initial length. Two modifications of this welded bellows construction are described: a standard ("male") type for most applica-

(Continued on page 36)

# IMITATION COCONUT BY FIRMENICH

*gives your products the true and complete flavor of the meat of the coconut*

Your coconut-flavored products enjoy the sweetness and freshness of a newly opened coconut itself when you fortify them with Coconut Flavor by Firmenich. For Firmenich has captured this delicious flavor . . . reconstructed it for you by original research . . . prepared it for you as a precise and potent flavor material . . . of the utmost purity and stability . . . to enhance the appeal of your cake mixes, ice-cream, candy, all the foods and confections that you flavor with coconut.

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FIRMENICH INCORPORATED

250 West 18th Street, New York 11

## FOOD INDUSTRY TOPICS

(Continued from page 34)

tions and a "nesting" type designed to provide extreme flexibility and very long expansion ranges. A specification sheet listing engineering information required for ordering is also included.

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The first non-electric, magnetic Sausage Trap (reg. trademark) for removing ferrous metal from coarse sausage grinds up to one inch has been announced by CESCO, 4025 Sebastopol Hy., Santa Rosa, Calif. The new Model 195 is completely described in CESCO Bulletin No. 191. A companion unit to the CESCO Model 190, which has found wide acceptance for use on frankfurters, bologna, liverwurst, and other emulsions, the new, larger Model 195 is designed to provide efficient handling of grinds of more than ⅛" plate. When installed between the stuffing valve and stuffing horn, it will remove ferrous particles ranging from tiny specks to broken cutter blades and stray metal tag clips—important to packers using frozen meats.

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The versatility of glycerine as an ingredient in commercial formulations is the subject of a bulletin published by the Glycerine Producers' Assn., 295 Madison Ave., New York 17, N. Y. The booklet discusses six properties of glycerine and shows how manufacturers have put these properties to work in new products. In each case, the formulator's problem is detailed, followed by a description of how glycerine enabled him to solve it.

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As always, the 48-page, third quarter 1953 issue of *Instrumentation*, published by Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne and Windrim Aves., Philadelphia 44, Pa., is loaded with interesting features. Included in the contents of the third quarter issue are stories on pressurized blast furnaces at Republic Steel Corp.; how a Btu controller at Iowa Public Service Company gas plant paid for itself in less than six months; the way Julius Kayser & Co., Ltd., used instruments to help double production of nylon tricot fabric; how Canadian Celanese Ltd. increased production 25 percent. Also included is information on basic optics, automatic amperometric titration, carbon black production, test room control, recovery of hydrocarbons, and the training of instrument engineers.

From Honeywell also comes Bulletin P-811 covering the Honeywell new 077 ElectroniK Temperature Controller, with range now extended to cover minus 100° F. to 600° F. The bulletin also contains complete specifications, prices, and application information on the controller in both the single-point and the new cascade model, as well as data on resistance thermometer elements and wells, and Modutrol motors and Industrial Control motors suitable for use with the new 077.

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A new, 24-page descriptive catalog covering dairy products, nougat creams, bakery ingredients, and fountain toppings has just been published by White Stokes Co., Inc., Chicago, manufacturer of ingredients for the confectionery, bakery, and fountain trade. The company's address is 3615 S. Jasper Place.

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A new, illustrated 8-page booklet, "Food Technology," describes the services which Foster D. Snell, Inc., consulting chemists and engineers, offer to the food industries. The activities described include packaging, flavor evaluation, quality control, product development, food engineering, and trouble shooting. Some of the problems usually encountered by the food industries and discussed in the booklet are: conformance to government regulations; physical inspection; advertising and labelling claims; food contamination; off-flavors; and spoilage. Write the company's Public Relations Department for free copies.

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"An Introduction to Clad Metals," the first publication to cover this vital field, has just been announced by the Superior Steel Corp., Carnegie, Pa. Written by Mr. Walter L. Keene, Superior's director of Research and holder of many basic patents in metal cladding, it offers a comprehensive survey of the manufacture and applications of stainless, copper, brass, and other clad steels. Headings include a "General Introduction," "Definition of Clad Metals," "Principles of Bonding," "Characteristics of Clad Metals," "Methods of Cladding," and "Applications." The booklet is profusely illustrated and shows the basic equipment and processes used in the varied cladding methods attempted in the past, as well as those now in production use.

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A new unit-type electrophoresis-diffusion instrument featuring double sensitivity in an optical system based upon double passage through the cell is described in a new folder identified as Form 8H853 by the manufacturer, Specialized Instruments Corp., 704 O'Neill Ave., Belmont, Calif. Suggested for application in the analysis, study, and identification of electrically-active particles in biological and chemical research fields, the new unit is illustrated in detail. Descriptions are given of the five individual optical facilities included; of the automatic photography and controls; the controlled-temperature bath; the refrigeration unit; the rotary cell turret which accommodates three cell assemblies, and the automatic, calibrated, and electronically-regulated current supply. Specifications are given on dimensions, weight, electric power, and cell power-supply characteristics.

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*Fatty Acid News Digest*, published by the Fatty Acid Division, Assn. of American Soap & Glycerine Producers, Inc., 295 Madison Ave., New York 17, N. Y., presents, among other items in its October number, leads to articles and literature on the handling of fatty acids, polymerized fatty acid, acetostearic protective coatings, crodacol fatty alcohols, sunaptic acids, formation of trans isomers during the hydrogenation of glyceride oils, fats in feeds, and paper chromatography as applied to separation and identification of fatty acids.

### . . . building up and branching out

A new and modern factory for the manufacture of perfume raw materials has been erected in Sao Paulo, Brazil, by Companhia Brasileira Givaudan, an associate company of L. Givaudan & Cie., S. A., Geneva, and Givaudan-Delawanna, Inc. The new plant is the first to bring industrial production of synthetic aromatic materials to Brazil to supply the ever-growing needs of the soap, perfumery, and foodstuffs market in South America. The plant was erected after years of study and careful planning, and is under the direction of Messrs. Emile Brauen, Leon Givaudan, and Ottavio Zuccari. It is equipped to produce not only aromatic derivatives of the essential oils readily available in Brazil, but also many other perfume materials that may be required.

(Continued on page 38)

## *for taste-appeal that sells*

# use GIVAUDAN FLAVORS...products of creative imagination

Perhaps you are seeking a new flavor—something truly distinctive, truly appealing.

Or perhaps you would like to re-evaluate your present flavoring materials in the light of your product's purpose, its market and price considerations.

Or your problem may be one of quality-control of flavor, to protect the distinctiveness and uniform taste-appeal of your product.

At Givaudan you will find the answer to all these problems and many others. Here, *creative imagination* on the part of Givaudan's flavor experts inspires the development of quality-controlled flavors with maximum taste appeal.

Givaudan Flavors Inc.

330 West 42nd Street, New York 36, New York

## FOOD INDUSTRY TOPICS

(Continued from page 36)

In answer to its expansion needs, the Aseptic-Thermo Indicator Company, founded 20 years ago in Los Angeles, has moved out of the city proper and opened its own new plant in the San Fernando Valley. One of the

FAMED FOOTBALL STAR AND SPORTSCASTER, TOM HARMON (LEFT), JOHN S. BECKETT, TECHNICAL DIRECTOR OF THE ASEPTIC THERMO INDICATOR CO. (CENTER), AND DR. PHILIP BATES, PRESIDENT-ELECT OF THE INSTITUTE OF FOOD TECHNOLOGISTS, AND RESEARCH MANAGER OF THE CARNATION MILK COMPANY, LOS ANGELES (RIGHT), POSE IN FRONT OF ONE OF THE COMPANY'S TEST RETORTS AT THE RECENT OPENING OF A-T-I'S NEW PLANT IN NORTH HOLLYWOOD. HARMON, MAYOR OF NORTH HOLLYWOOD, WAS AT THE OPENING TO WELCOME A-T-I TO THE COMMUNITY.

world's largest manufacturers of sterilization indicators, A-T-I is well-known in the food processing industry for its Cook-Chex device, widely used by canners for quality control. According to Mr. Willard M. Huyck, president and general manager, the move was long overdue since over 250 million Cook-Chex and Steam-Clox devices have been sold to date. The latter, similar to Cook-Chex, are standard equipment today in many hospitals and pharmaceutical houses and are utilized in all sterilization processes to determine the positive sterility of surgical equipment. Contained in the new plant are the executive offices, employees' recreation lounge, a complete printing establishment, a modern laboratory, and A-T-I's fully-developed Autoclave department. This department contains four specially-designed autoclave sterilizers, used to test every batch of indicators during all stages of production. The laboratory is fully equipped for research work constantly underway on many types of problems connected with sterilization, thermal death times, and the development of new products for the hospital and food processing fields.

◆ ◆ ◆

Construction has begun on a new $150,000 building to house the insecticide and animal laboratories of the Wisconsin Alumni Research Foundation (WARF), it was announced by Mr. Ward Ross, managing director of the Foundation. The building will be constructed as a separate unit immediately behind the present Foundation building at 506 N. Walnut St., Madison, Wis. With the new building, expected to be completed by March 1954, the 35 members of the Foundation's technical staff will continue their control work, research, and development in chemistry, biochemistry, bacteriology, entomology, pharmacology, and food technology —some Foundation-financed, and others sponsored by individual companies or associations throughout the nation. Typical of the sponsored research is a complete analysis of 700 frozen food samples currently being financed by the National Assn. of Frozen Food Packers.

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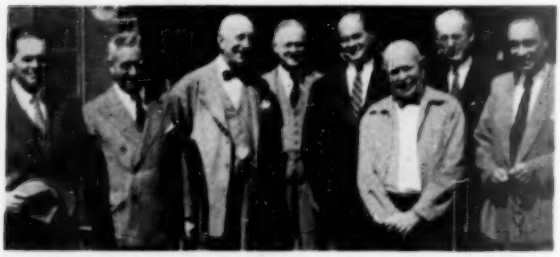
A group of National Starch Products directors and management officials journeyed to the company's Indianapolis plant to inspect the many improvements being carried out under the firm's expansion plans. Mr. Herb Piel, vice president and



NATIONAL STARCH GROUP INSPECTS COMPANY'S PLANT. LEFT TO RIGHT—EDWARD CONWAY, FRANK GREENWALL, CHESTER GAGE, EVANS WOOLEN, JR., BERNARD SCHULIST, HERB PIEL, WILLIAM SCHILIGES AND A. A. HALDEN.

general manager of the Indianapolis plant, guided the group during the tour. Of particular interest to the visitors was the new and unique "by-products building" installation, soon to be put into operation. Also on hand to greet the visitors were Mr. Frank Greenwall, president, and Mr. A. A. Halden, executive vice president from the New York executive offices.

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Sandvik Steel Belt Conveyors, Division of Sandvik Steel, Inc., New York City, announces the opening of new sales offices at 230 N. Michigan Ave., Chicago, Ill. The office, under the direction of Mr. Arve Larsson, is prepared to provide information and engineering assistance for various types of steel band conveyors throughout the midwestern territory.

### . . . *meeting hall and conference room*

Sucaryl-sweetened beverages will increase in carbonating ability and gain a smooth, natural feel in the mouth if a hydrophilic colloid is used as a bodying agent, Dr. Karl M. Beck of Abbott Laboratories told members of the National Manufacturers of Soda Water Flavors in Chicago on November 9. Dr. Beck named algin, carboxymethylcellulose, methoxycellulose, pectin, and sorbitol as bodying agents now being successfully used to increase the viscosity and surface tension of Sucaryl-sweetened beverages. Dr. Beck declared that the synthetic sweetener, which is 30 times as sweet as sugar, is chemically unreactive. That is, Sucaryl can be used in foods and beverages without affecting or being affected by the other ingredients, or by cooking. Even the human body passes it on undisturbed, he pointed out. He reviewed current legislation on syn-

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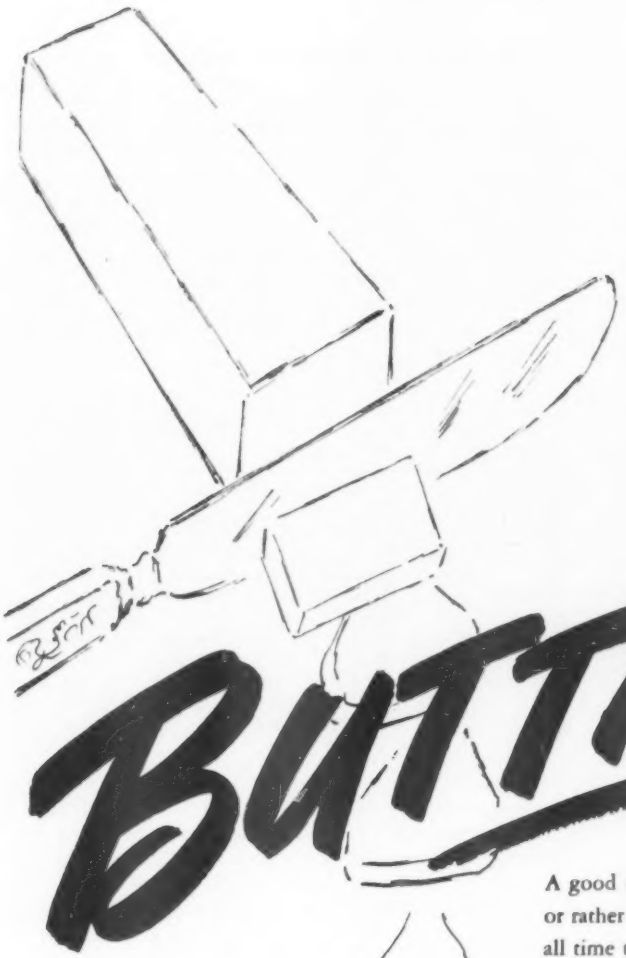

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ESTABLISHED 1798

PRESENTS

# BUTTATONE

A good synthetic butter flavor is traditionally "hard to find"... or rather WAS! Now this perennial phrase may be relegated for all time to the past tense... for the D&O Product Development Labs have created BUTTATONE! The fresh, very natural butter effect of this new compound (from which the usual harsh, synthetic character has been completely eliminated) makes possible a wide application in the food and confectionery industry. Candies, ice cream, dairy products, oleomargerine, baked goods, icings, chocolate items, mixes and canned foods... BUTTATONE may be used to advantage in all. A concentrated water-soluble flavor, based on a pure milk distillate, and supplemented with aromatic materials, BUTTATONE is also available in oil soluble form. Price in single gallon quantities . . . $7.00. Ask your D&O representative for trial amounts.

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## FOOD INDUSTRY TOPICS

(Continued from page 38)

thetic sweeteners and named three established factors that are influencing possible law changes: (1) approval of Sucaryl by the Food and Drug Administration; (2) Sucaryl's acceptance by the AMA; and (3) Sucaryl's value to persons who must avoid sugar for health reasons.

◆ ◆ ◆

Maintenance problems in the food processing and packaging field will again receive special attention at the next Plant Maintenance and Engineering Show which will be held in Chicago, January 25-28, it was announced by Clapp & Poliak, Inc., producers of the show and the Plant Maintenance and Engineering Conference which will run concurrently. Hundreds of new products, especially useful in the maintenance of food processing and packaging plants, will be on display in the booths. The exposition will take place at the International Amphitheatre while the conference will be held at the Hotel Conrad Hilton. Two round-table conference sessions have been set aside for exclusive consideration of food processing and packaging problems. Fifty-nine conference sessions are scheduled—many of special interest to the food field. Particular types of equipment used in the food field will get special attention at separate sessions. Advance registration cards may be obtained from Clapp & Poliak, Inc., 341 Madison Ave., New York 17, N. Y.

### . . . the human element

The election of Mr. Clarence Francis to the board of directors of Bendix Aviation Corporation has been announced by Mr. Malcolm P. Ferguson, president. Mr. Francis has been board chairman of General Foods Corporation since 1943. He is a director of several other corporations and is also active on committees concerned with long-range government-industry policy. The new Bendix board member is a director of the Federal Reserve Bank of New York and was recently named chairman of the Citizens' Committee for the Hoover Report.

◆ ◆ ◆

Engagement of Mr. John J. Morey to handle the new ice cream and dairy sales operations of Felton Chemical Co., Inc., Brooklyn, N. Y., flavor and essential oils manufacturer, was announced last week by Mr. Louis Gampert, executive vice president, and Mr. Frank Brumburgh, sales manager. Widely known in ice cream industry circles, Mr. Morey has been designated as director of the Dairy Sales Division of Felton. For the past 12 years, he has been treasurer of the Empire Flyers, the supply group connected with the Assn. of Ice Cream Manufacturers of New York State. He also formerly served as a director for the Association. In his new post, Mr. Morey will be responsible for sales to the ice cream and dairy trades of Felton's pure vanilla, pure citrus emulsions, novelty flavors, ingredients of all kinds, and special products. He will work in close contact with the company's representatives and visit various centers throughout the East where dairy foods processing operations are conducted.

◆ ◆ ◆

Celanese Corporation of America announces that Mr. Paul Conaway has joined its Plastics Division as a sales representative in the Midwest District, with headquarters at 1514 Merchandise Mart, Chicago, Ill. Mr. Conaway formerly was with Reynolds Metals Co.

◆ ◆ ◆

Appointment of Mr. Bernard H. Schenk of Lindsay, Ont., as president of Visking, Ltd., Canadian subsidiary of Visking Corp., Chicago, has been announced. At the same time, it was announced that Mr. J. Paul Smith, president of the parent company, also would become

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chairman of the board of the Canadian subsidiary. He formerly was president of Visking, Ltd. Mr. Schenk, an American citizen, had been vice president of Visking, Ltd., since 1951 and a director of the Visking Corporation since early 1953. In addition to his duties as president of Visking, Ltd., Mr. Schenk will be in charge of Visking's international operations and will serve as a director of the corporation's international subsidiaries and affiliates. The company manufactures sausage casings, polyethylene film for the packaging and conserving of food products and many other uses, and nonwoven fabric.

◆ ◆ ◆

The 100th Anniversary of the birth of Dr. Jokichi Takamine, the founder of Takamine Laboratory, Inc., oldest manufacturer of industrial enzymes in the U. S., was celebrated the first week of November at his home town, Kanazawa City, Japan. The celebration was attended by Mrs. Eben T. Takamine, president of Takamine Laboratory, Inc., Clifton, N. J., and widow of Dr. Takamine's younger son; Mr. Homer C. Fritsch, executive vice president of Parke, Davis & Company and a member of the board of directors of Takamine Laboratory, Inc.; and Mrs. Fritsch. Most of Dr. Takamine's work in the pharmaceutical field was in cooperation with Parke, Davis and closest connections have been maintained between that company and Takamine Laboratory for over 50 years. Also attending the ceremonies were the 20 Japanese students who have received the Dr. Takamine Award under the direction of Kanazawa University. This annual student award is supported by the Laboratory. Dr. Takamine's best known and most important accom-

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## FOOD INDUSTRY TOPICS

(Continued from page 41)

plishment is the isolation of pure adrenalin and the process of its manufacture from adrenal glands, which he announced in 1901. Another of Dr. Takamines outstanding contributions to the drug field is the enzyme Taka-Diastase which promotes the digestion of starchy foods and counteracts dyspepsia. This enzyme, derived from cultures of a selected strain of Aspergillus in its production methods predated the development of fermentation antibiotics.

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FOOD RESEARCH, also published by the Institute of Food Technologists, is a bi-monthly journal addressed to food scientists engaged in the more basic types of food investigation. Its coverage over a typical publishing year includes reports on bacteriological investigations relating to food, chemical studies on such major food problems as browning and oxidative deterioration, methods for the sensory evaluation of foods, sterilization of foods by the newer experimental methods—for example, irradiation—and numerous other topics. FOOD RESEARCH has maintained an enviable record in the nearly 20 years of its history; it has published contributions from leading food laboratories and outstanding food scientists both in the United States and overseas. The selection of subject matter is broad; the journal has never been the captive of one science or of one school of thought. For further details write Charles S. Lawrence, Business Manager, Institute of Food Technologists, 176 West Adams Street, Chicago 3, Ill.

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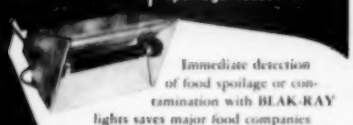
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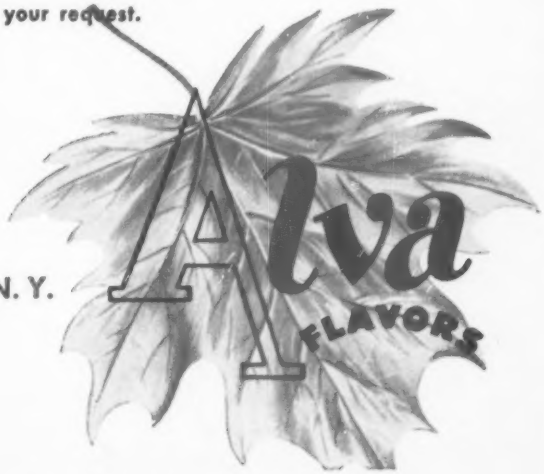


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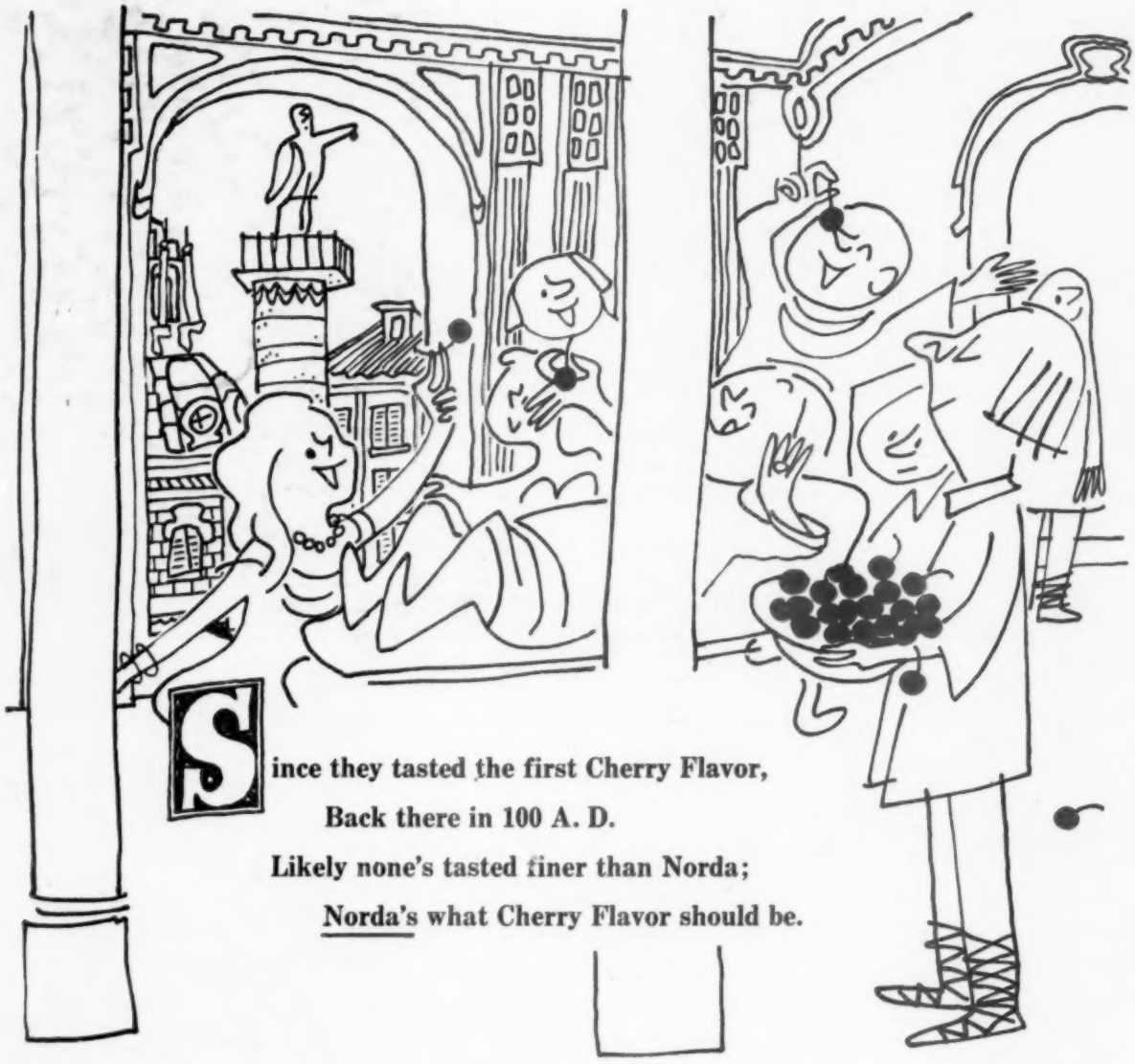

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